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STATIC AND DYNAMIC TESTING OF AN AXLE SHORED MHU-141/M TRAILER

Grant W. Gray

February 1976

Final Report

Approved for public release; distribution unlimited.

AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base, NM 87117

AFSWC-TR-75-24

This final report was prepared by the Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, under Job Order 12990001. Mr. Grant W. Gray (FTET) was the Air Force Special Weapons Center Project Officer. The Air Force Armament Laboratory Project Officer was Mr. B. B. Armbrester (DLJA). Mr. D. E. Calfee (SD22) was the Armament Development Test Center Program Manager. Mr. L. W. Short (SEEC) was the Air Force Weapons Laboratory Project Monitor.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An MHU-141/M Munitions Handling Trailer, loaded with two AGM-69 SRAM missile shapes on MHU-71/E Munitions Handling Rail Sets, was subjected to simulated inertial load tests and vibration tests in the 1 to 20 Hertz range. The trailer, tied down to simulated aircraft deck with 10,000-pound rated chains and MB-1 tiedown devices, was tested with and without shoring to provide data on the effectiveness of the shoring. Data on tiedown chain reaction loads and trailer response were acquired. The tiedown pattern and procedures (OVER)

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ABSTRACT (Cont'd)

tested satisfy the inertial load test criteria for air transport. No hazardous reaction loads or trailer response was observed. Test procedures, complete data, and test observations are presented in the report.

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SECTION I

INTRODUCTION

1. GENERAL

The MHU-141/M Munitions Handling Trailer is the projected replacement for the MHU-12/M Munitions Handling Trailer for transport of nuclear weapons. These two trailers are very similar in appearance, but the MHU-141/M Trailer has a stronger undercarriage and will be rated at 5500 pounds load capacity, as compared to the 5000 pound rated load capacity of the MHU-12/M Trailer. This higher load rating provides for transport of two AGM-69 SRAM missiles which physically fit but exceed the load rating of the MHU-12/M Trailer (ref. 1).

Dynamic tests, which simulated the flight conditions of cargo aircraft, on an unshored MHU-12/M Trailer (ref. 2) indicated that the trailer could be excited to resonant frequencies. This could cause amplified motion and result in impact loading of the trailer tiedown chains. As a result of these tests, the unshored MHU-12/M Trailer loaded with nuclear weapons was considered unsafe for air transport.

The Air Force Armament Laboratory (AFATL) has designed an axle shoring method for air transport to eliminate the tires from the spring-mass system on the MHU-141/M Trailer. Testing was required to provide data for the safety evaluation of this shoring design.

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1. Krek, Frank T., Nuclear Safety Evaluation Testing of the AERO 51B Trailer/MHU-71/E Rail Set for the AGM-69 (SRAM) System, Technical Report AFSWC-TR-73-31, Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, April 1974.

2. Krek, Frank T., Static and Dynamic Testing of the MHU-12/M Trailer, Technical Report, AFSWC-TR-72-30, Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, July 1972.

2. PURPOSE

These tests were requested to provide data on the structural integrity and performance of the AFATL-designed axle shoring on the loaded MHU-141/M Trailer under simulated flight load conditions. The tests were also intended to provide data on the structural integrity and behavior of the MHU-141/M Trailer under the simulated flight load conditions.

3. SCOPE

This testing was initially limited to a single load configuration, two AGM-69 SRAM missiles on the MHU-71/E Munitions Handling Rail Set. Testing was required under static application of simulated inertial loads and under low frequency vibration simulating flight load conditions.

4. AUTHORITY

This effort was authorized by AFSWC Form 43, AFSWC Management Plan, for Project 1299 issued by Headquarters, Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, on 6 November 1974, "Static and Dynamic Tests of an Axle-Shored MHU-141/M Trailer".

SECTION II

SUMMARY OF TESTS

1. DESCRIPTION OF TEST ITEM

The MHU-141/M Trailer is an adaptation of the Navy Aero 51 Munitions Handling Trailer for Air Force requirements. The Aero 51 Trailer is an adaptation of the Air Force MHU-12/M Trailer for Navy requirements. Thus, the three trailers are very similar in design and appearance, except for the lower rated load capacity of the MHU-12/M Trailer. The trailer furnished for these tests was a Navy Aero 51B Trailer, Serial Number GMGM 71391.

The Aero 51B Trailer is a four-wheeled, pneumatic-tired vehicle with automotive type steering, leaf spring suspension, and hydraulic brakes actuated by an inertia system on the tow bar. The trailer has a maximum width of 84 inches, a maximum length of 126 inches (not including the tow bar), and a height of approximately 32 inches at the top of the deck. It weighs 2781 pounds empty and 3433 pounds with the MHU-71/E Rail Set, two pairs of MHU-69A/E Cradles, and two MMU-125/E Handling Fixtures mounted on the trailer deck. It has four 25,000-pound rated tiedown rings on each side and two on each end of the trailer deck. The empty Aero 51B Trailer is shown in figure 1.

The AFATL-designed shoring is a steel jack stand clamped by a yoke to the trailer axle. One jack stand is mounted at each end of each axle just inboard of the leaf springs. Each jack stand has a foot plate for load distribution on the aircraft deck. The jack stands are intended to be mounted permanently to the trailer and are designed to pivot up against the axle for storage when not in use as shoring. Figure 2 shows a jack stand mounted on the axle in the stored position. Figure 3 shows the jack stand in position as axle shoring.

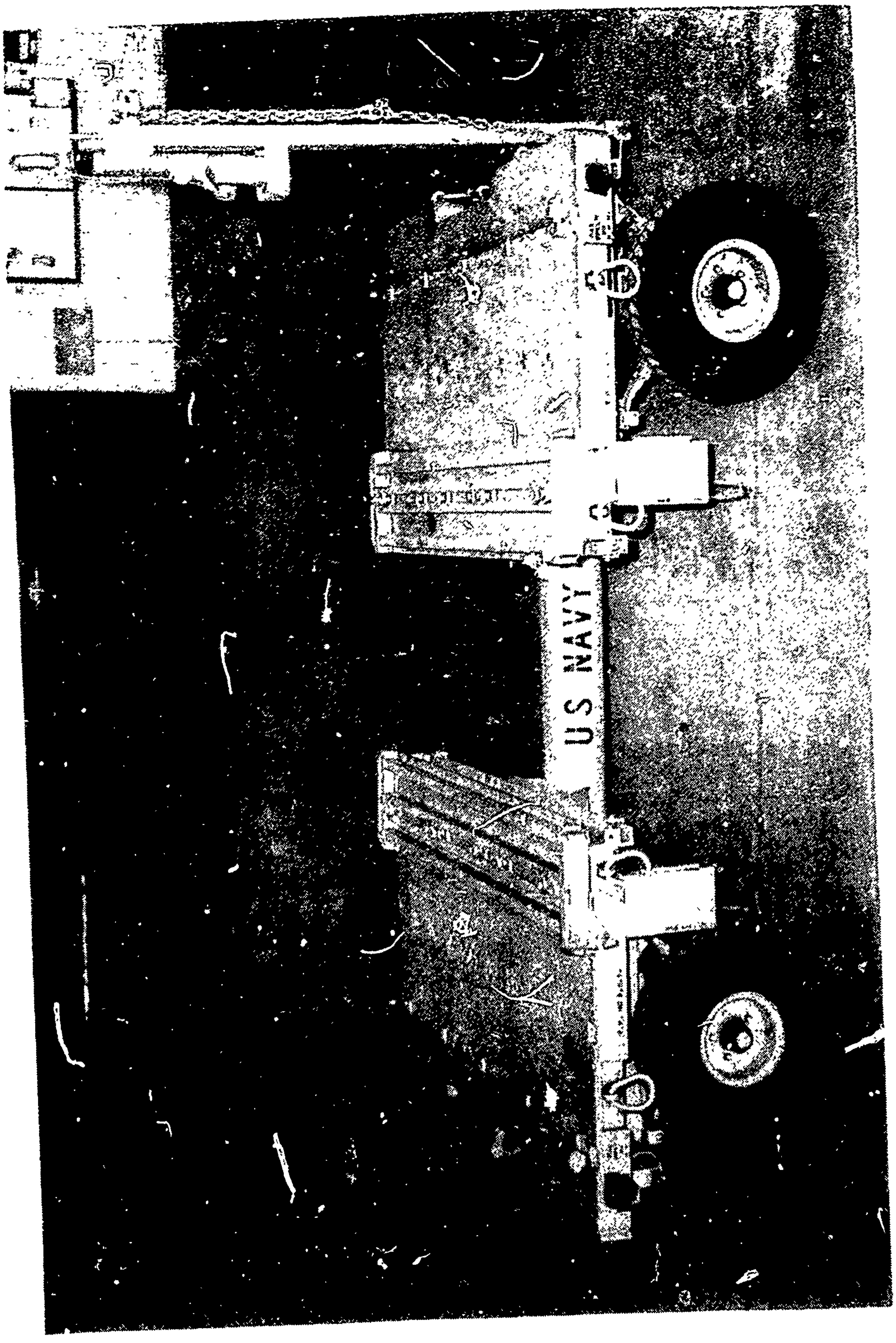


Figure 1. Aero 51B Trailer

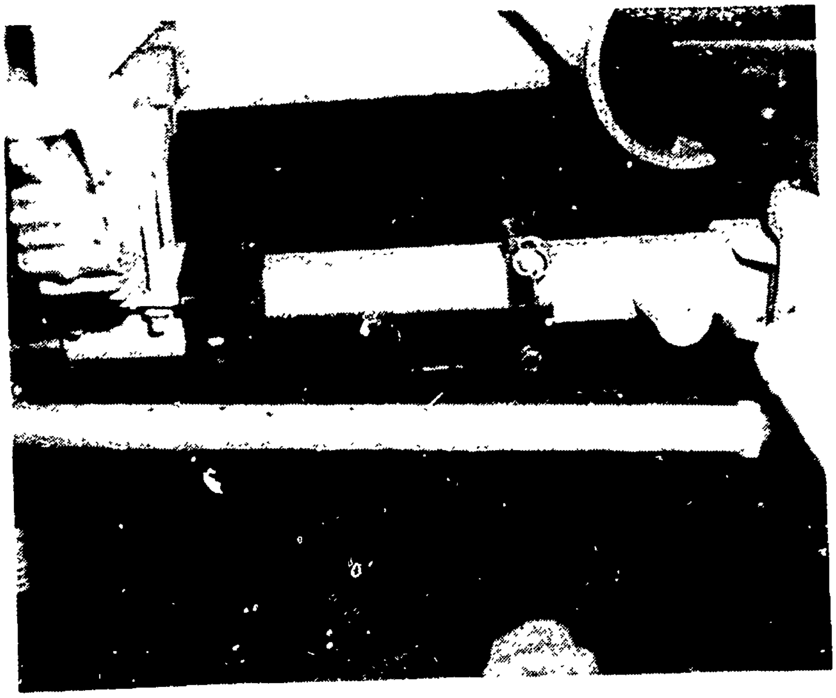


Figure 2. Jack Stand in Stored Position

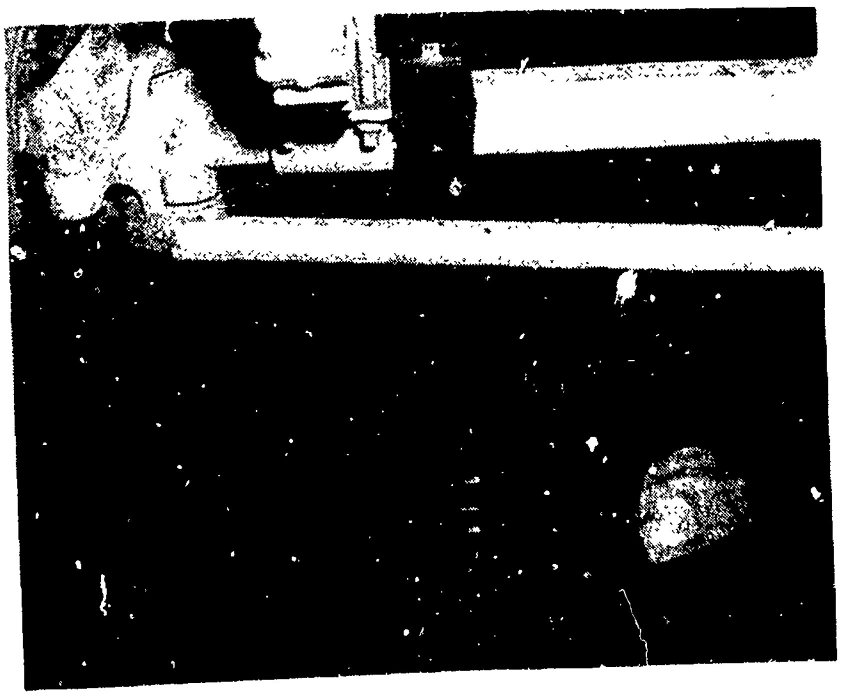


Figure 3. Jack Stand in Position as Axle Shoring

2. TEST REQUIREMENTS

The following test requirements were compiled from the AFATL Test Plan.

a. General

Testing will be accomplished in a simulated aircraft environment to determine the adequacy of the AFATL axle shoring for air transport of a loaded MHU-141/M Trailer.

b. Test Configurations

The MHU-141/M Trailer will be loaded with two dummy shapes, each having the physical characteristics of the AGM-69 missile, centered on the trailer with the MHU-71 rail sets and secured with 10,000-pound rated chains and MB-1 tiedown devices instead of the nylon straps, the same method used in previous tests of the Aero 51B Trailer (ref. 1).

The trailer will be tested with the AFATL shoring between the trailer axle and the simulated aircraft deck.

The tiedown configuration used shall be the tiedown configuration determined in the static and dynamic tests of the MHU-12/M Trailer (ref. 2).

c. Static Load Test

The tied down, shored trailer and the transported weapons shall be statically loaded to the maximum simulated aircraft load acceleration conditions specified in AFSCM 122-1, <u>Nuclear Systems Safety Design Manual</u>. The required loads are:

Forward	4.0g
Aft	1.5g
Side	1.5g
Upward	3.7g + TARE
Downward	4.5g - TARE

The upward load requirements were established from aircraft load reports based on operational data. The specified upward load is the ultimate load based on structural design criteria. The restraint force in any tiedown chain shall not exceed 10,000 pounds.

d. Dynamic Load Test

The loaded, shored trailer with the same tiedown configuration shall be subjected to low frequency vibration tests from 0 to 20 Hz with sine wave inputs to be established at approximately 1000, 2000, and 3000 pounds peak. If a resonant frequency is found, the test will be rerun, and color motion pictures will be taken to record the characteristics of the trailer response.

e. Instrumentation

Color motion picture coverage is required to record trailer response at each resonance. Black and white still coverage is required for documentation purposes.

Strain links will be inserted in each tiedown chain to monitor the restraining force transmitted to the tiedown points.

Three accelerometers will be used during the dynamic test; one mounted on the aft end of the trailer, one similarly mounted on the forward end of the trailer, and one on the simulated aircraft deck. These locations will allow a comparison of the input acceleration to the trailer's reactive acceleration.

Two displacement transducers will be used during dynamic test; one at each end of the trailer deck as close as possible to the accelerometer locations. These will record the relative motion between the trailer deck and the simulated aircraft deck.

f. Reporting

A technical documentary report shall be provided, describing all test conditions and results and summarizing all quantitative data. Data presentation shall be similar to that of previous testing on the MHU-12/M Trailer (ref. 2) for easy comparison.

SECTION III

TEST PROCEDURES AND TEST RESULTS

1. STATIC LOAD TEST

With the MHU-71/E Rail Sets, the MHU-69A/E Cradles, and the MMU-125/E Handling Fixtures assembled on the Aero 51/B Trailer, the weight of the assembly was 3325 pounds. The two simulated SRAM missiles were weighed separately; one weighed 2155 pounds and the other 2135 pounds. Reference 1 lists the following weights:

Item	Weight-Pounds
Aero 51B Trailer	2781
MHU-71/E Rail Set	148
MHU-69A/E Cradles (Pair)	76
MMU-125/E Handling Fixture	102
AGM-69 Missile	2245
MMU-124/E Restraint Fixture	63

The simulated inertial loading was calculated using weights from this list as 1g. The actual weight of the test items was used for tare weight. The tire pressure was adjusted to the 85 pounds per square inch stenciled on the trailer. The towbar was removed for convenience in handling and fixturing.

The trailer with rail sets and cradles assembled was placed in the static test frame and tied down to the simulated aircraft deck, in the pattern shown in figure 4, using 10,000-pound rated chains and MB-1 tiedown devices. A strain link was inserted in each tiedown chain to monitor the restraining force transmitted to the tie points. The strain links were connected through bridge balance equipment to a data logging device, and the force in each tiedown was recorded for each increment of simulated inertial load. The AFATL-designed jack stands were attached to the trailer axles as shoring before the trailer was tied down.

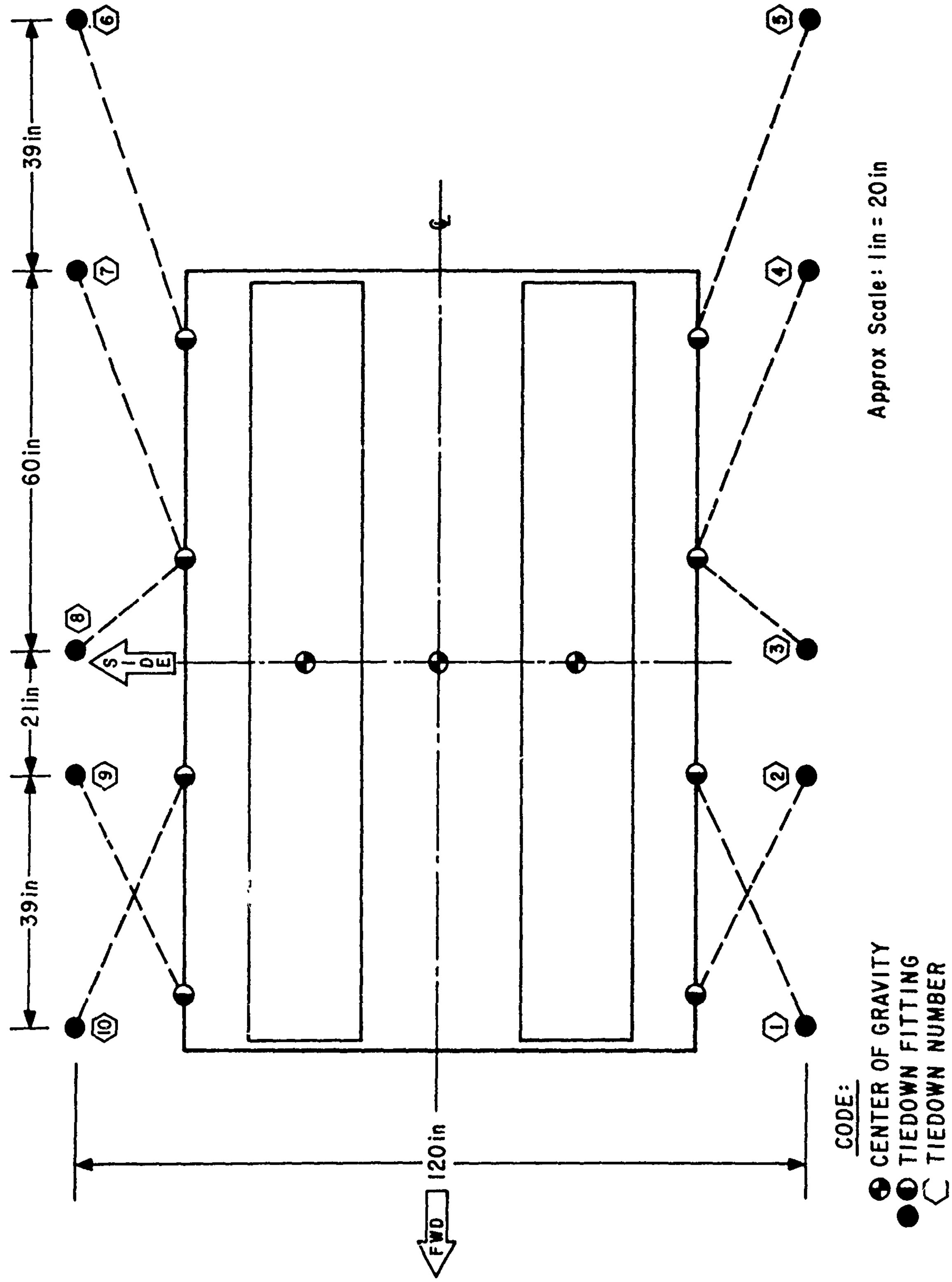


Figure 4. Tiedown Pattern for Static Load Tests

The missile shapes and restraint fixtures were mounted on the rail sets and tied down securely with 10,000-pound rated chains and MB-1 tiedown devices. Chains and fixtures were attached to each missile shape and connected through load cells to hydraulic cylinders mounted on the static test frame to apply simulated inertial loads through the center of gravity of each missile shape. Chains and fixtures were attached to the trailer and connected through load cells to hydraulic cylinders mounted on the static test frame to apply simulated inertial loads to the trailer separately. The structural tube in the center of the trailer approximates the trailer center of gravity and was used as the attach point. The load cells were connected through bridge balance equipment to indicators on the hydraulic control console to monitor load at each point. Figure 5 shows the test assembly in the test frame, the tiedown devices with strain links inserted, and the method of tiedown of the missile shapes to the trailer. Figure 6 shows the methods and fixturing used for application of simulated forward load through load cells. Similar fixtures were used for simulated loading in the other directions. Simulated inertial loads were applied in each direction in increments, with each increment held for at least 30 seconds. Because of the symmetry, load was applied to only one side.

The 4.0g forward simulated inertial load was applied first. On application of 50 percent load, tiedown chains No. 5 and No. 6 exceeded 50 percent of the 10,000 pound rating, indicating that the 100 percent load could not be applied without exceeding the tiedown chain rating. The load was released, and the tie rings on the trailer common to tiedown chains No. 3 and No. 4 and to No. 7 and No. 8 were reoriented by tightening chain No. 4 before No. 3 was tightened and by tightening No. 7 before No. 8 was tightened. The initial tie ring orientation is shown in figure 7 and the revised orientation in figure 8. This tie ring orientation was used for all of the simulated inertial load tests. Table 1 lists the tiedown chain restraining loads recorded during simulated inertial load tests.

Some creaking noise from the trailer was noted during application of simulated inertial loads and some motion of the trailer on the simulated

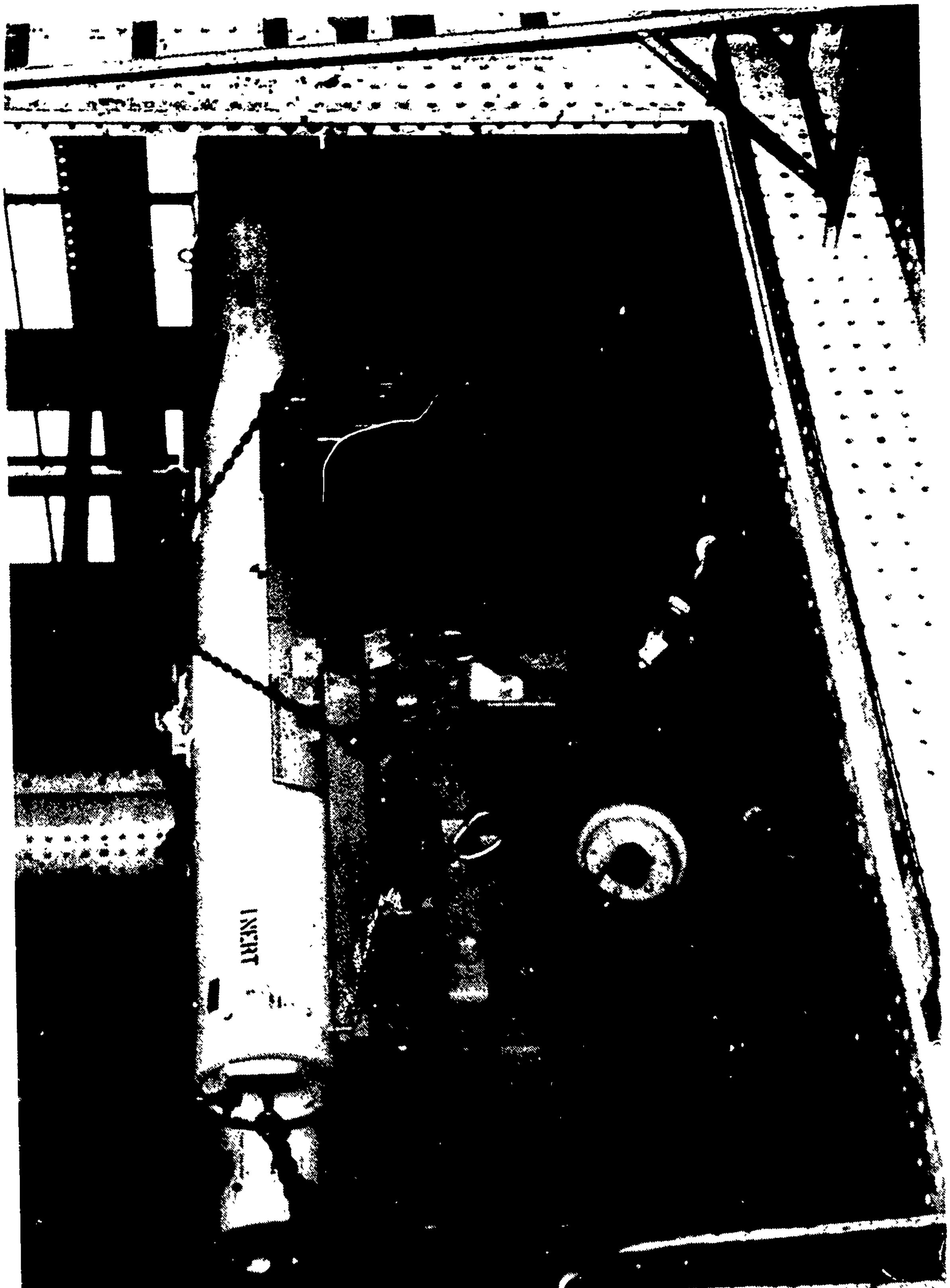


Figure 5. Static Test Assembly

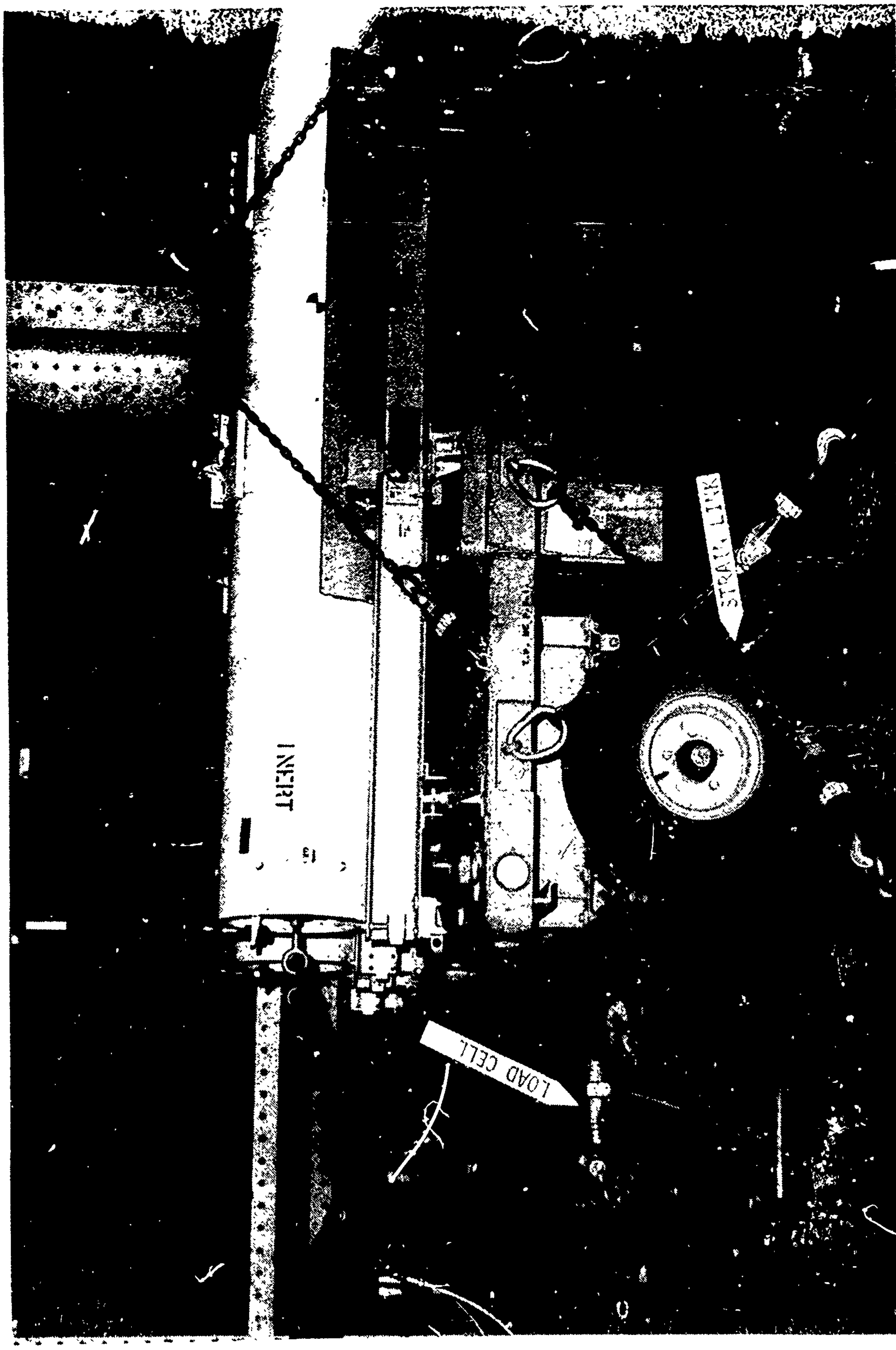


Figure 6. Typical Loading Fixtures

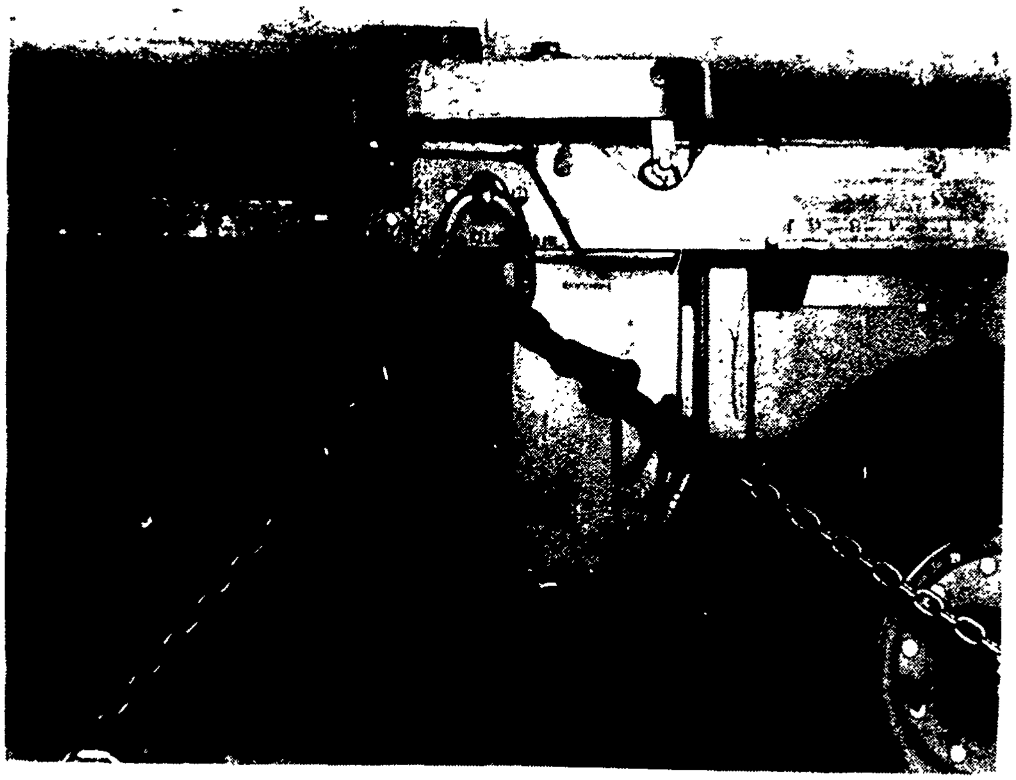


Figure 7. Initial Tie Ring Orientation

Figure 8. Revised Tie Ring Orientation

Table 1

SIMULATED INERTIAL LOAD TEST DATA

Load		Restraining Load - Pounds									
Direction	Percent	Chain 1	Chain 2	Chain 3	Chain 4	Chain 5	Chain 6	Chain 7	Chain 8	Chain 9	Chain 10
Fwd	50*	0	1775	0	125	5950	6075	25	0	2150	0
Fwd	50	0	2000	0	2000	4675	4800	1600	0	2175	0
Fwd	75	0	2725	0	3000	7000	7050	2350	0	3400	0
Fwd	100	0	4000	0	4250	8950	8700	3200	0	5025	0
Up	50	3975	2325	2900	2700	1225	700	3275	2500	2125	4575
Up	75	5850	3425	4425	3950	2000	1350	4500	3850	3225	7000
Up	100	7675	4350	6025	5100	3000	2150	5600	5400	4150	9250
Side	50	1600	1525	1250	1475	1000	0	0	0	0	0
Side	75	2700	2325	2025	2050	1225	0	0	0	0	0
Side	100	4050	3125	3475	3025	1950	0	0	0	0	0
Aft	50	2525	0	0	0	0	0	0	0	0	2600
Aft	75	3975	0	0	0	0	0	0	0	0	4200
Aft	100	5325	0	0	0	0	0	0	0	0	5775

* Initial tie ring orientation

deck. There was also motion of the missile shapes in the cradles and some bowing of the rails during simulated load application. None of this was considered unusual, and no permanent deformation was noted.

2. DYNAMIC LOAD TEST

A hydraulic-actuated floating table was assembled in the test frame to simulate the aircraft deck and to apply low frequency vibration inputs to the trailer. The table was the same type 1-inch thick steel plate used for the static load test bolted to 12-inch steel channel supports for rigidity. The table weight was 9860 pounds. The table was floated on four rubber inner tubes (truck tire size), sandwiched between plywood to provide a smooth contact on the rubber, and was driven by a 20,000-pound capacity Servoram (hydraulic cylinder designed for dynamic application). The Servoram was attached to drive the underside of the table through a 5000-pound rated, dual load cell to provide both feedback signal for control and force input signal data. The Servoram and load cell mounted under the table are shown in figure 9. Power to drive the Servoram was furnished by a 3000-psi, 100-gpm hydraulic console. Frequency and force inputs to the table were controlled by a Servac Programmer located at the hydraulic console. The Servac compares the feedback from the load cell with the output of a sine wave signal generator and programs a servo valve on the Servoram to control the hydraulic fluid. An electronic counter was used to monitor frequency, and an oscilloscope connected to the load cell signal allowed the operator to monitor force amplitude. The control equipment is shown in figure 10.

The trailer, loaded with the rail sets, cradles, and missile shapes, was placed on the table with the center of gravity located directly above the Servoram attach point. The same 10 chains, strain links, and MB-1 tiedown devices were used for tiedown as were used for static test. Dimensions of the table would not permit tiedown in the same pattern as used for static test. The tiedown pattern used for dynamic test is shown in figure 11. The loaded trailer on the table for test is shown in figure 12.

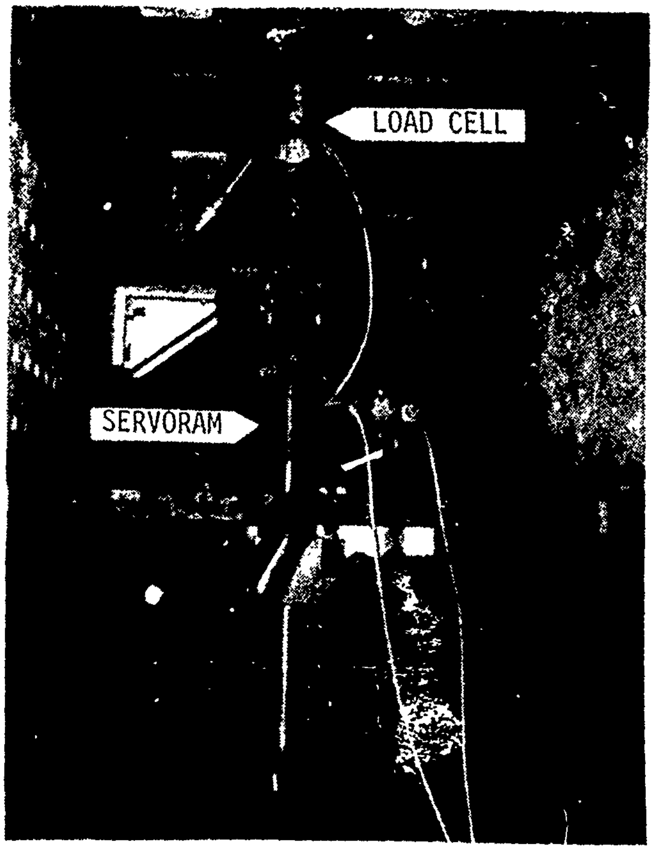


Figure 9. Servoram and Input Load Cell

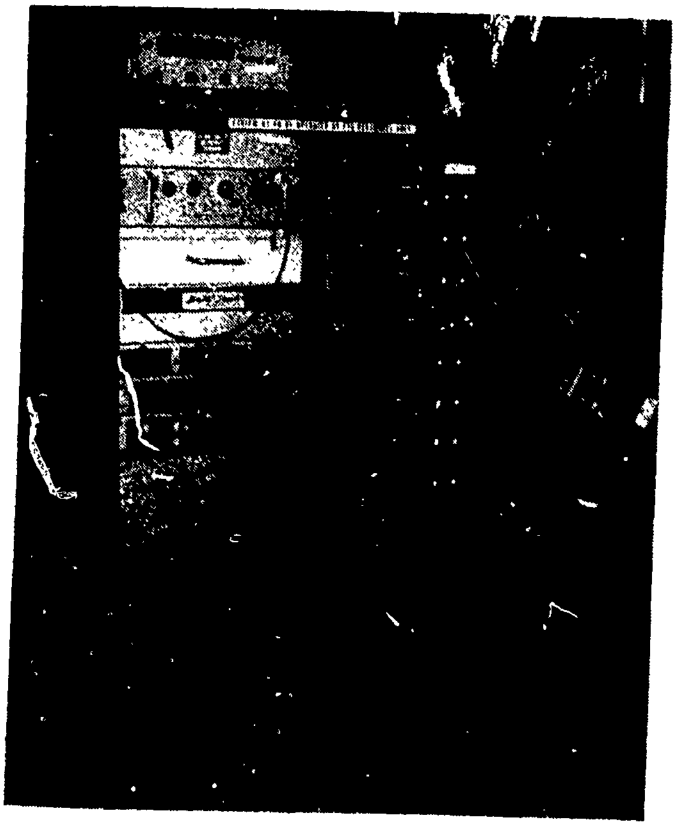


Figure 10. Control Equipment

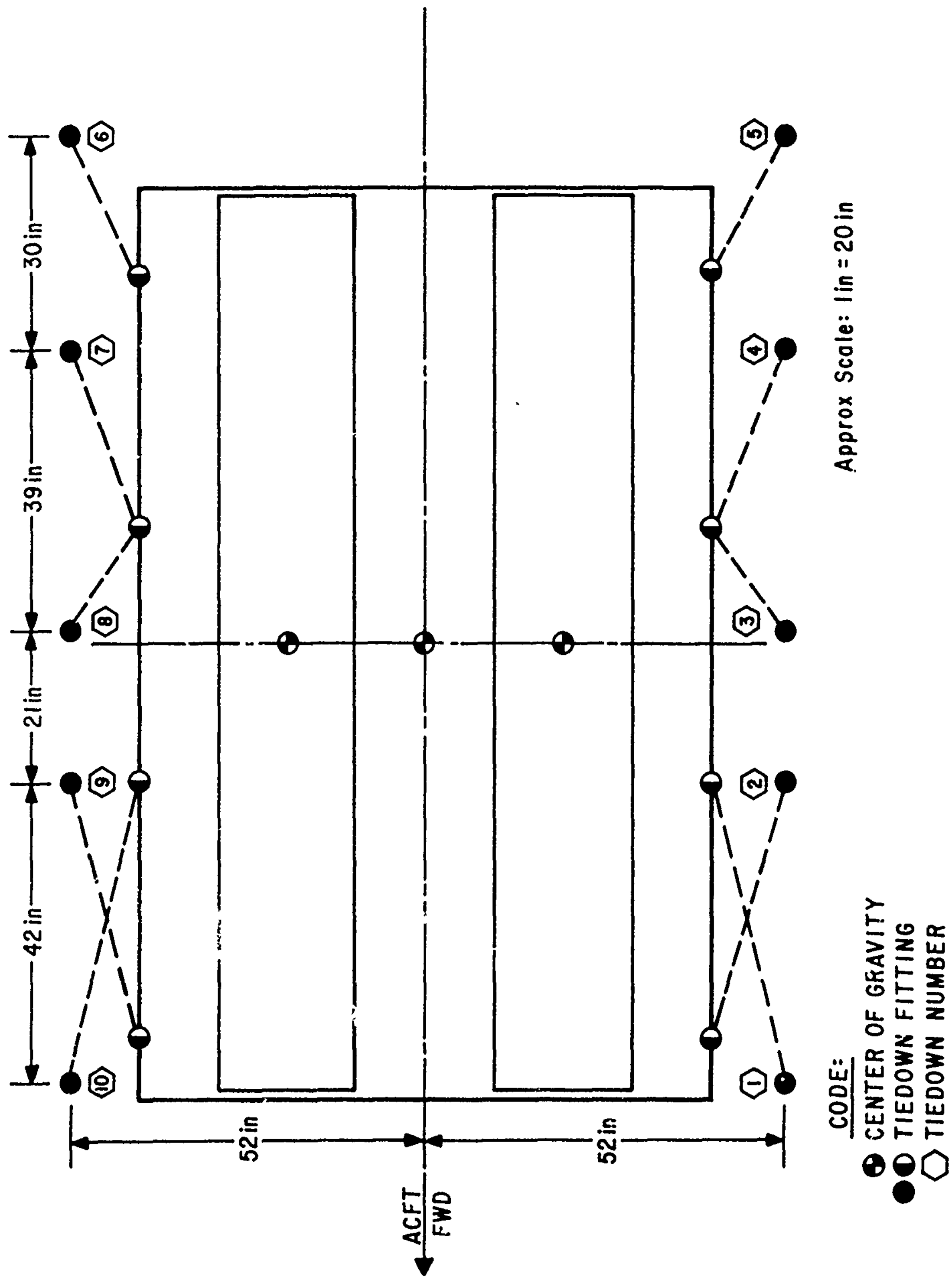


Figure 11. Tiedown Pattern for Dynamic Tests

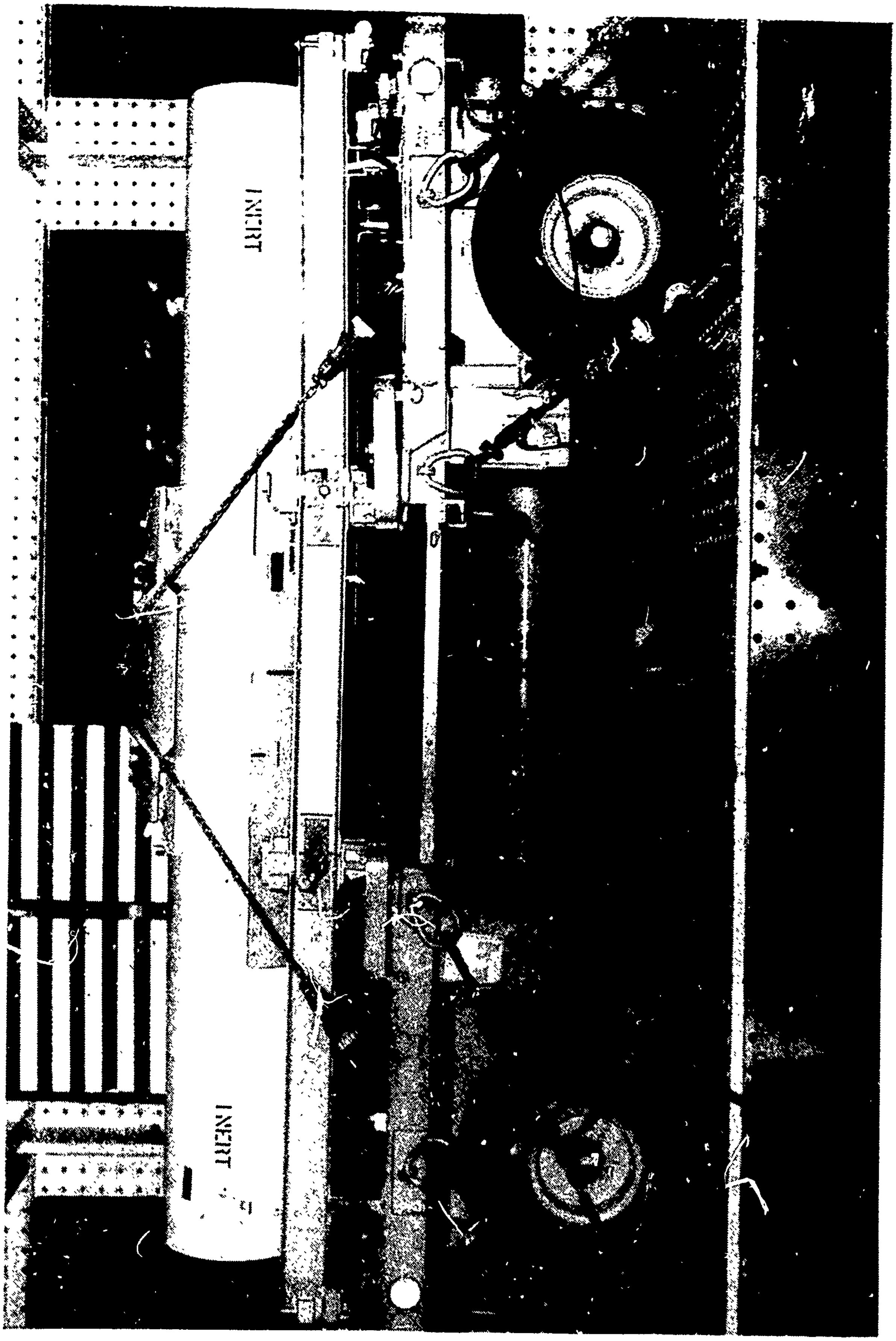


Figure 12. Dynamic Test Assembly

Instrumentation for the dynamic tests consisted of the 10 strain links, one in each tiedown chain, an accelerometer and displacement gage at each end of the trailer, an accelerometer in the center of the table, and the load cell on the Servoram. These transducers were connected through signal conditioning equipment and voltage controlled oscillators to a 14-track magnetic tape recorder. Figure 13 shows the general locations of the transducers. Figure 14 shows the location and mounting of the input accelerometer, and figure 15 shows the location and mounting of the accelerometer and displacement gage at one end of the trailer. Signals from the transducers were recorded continuously on magnetic tape during each test and then reproduced and recorded on a strip-chart recorder. The data from the strip-chart recorder were reduced to engineering units and plotted using a small computer.

The same procedure was used on each test; transducer calibration signals and base line signals were recorded with the tiedown chains slack, then the chains were tightened to a preload of approximately 300 pounds and the preload recorded. Starting at a frequency of 1 Hertz, the frequency was increased in

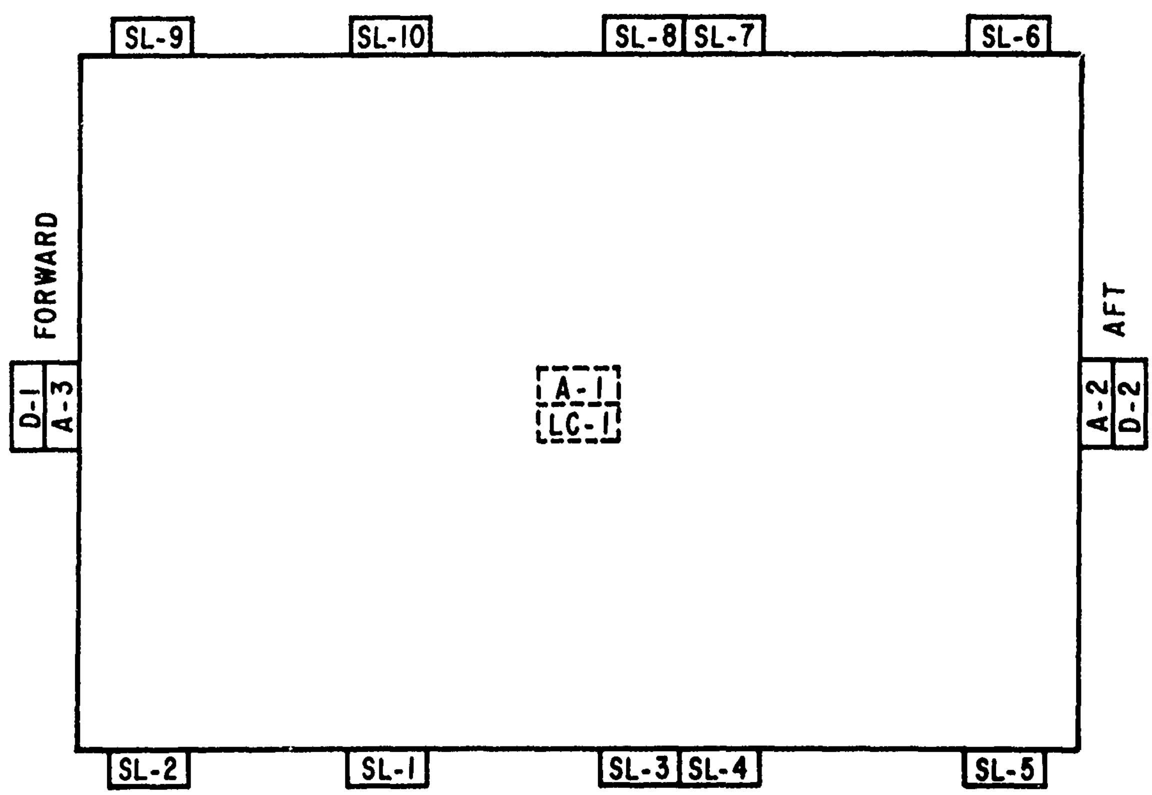


Figure 13. Transducer Locations

Figure 14. Input Accelerometer Location

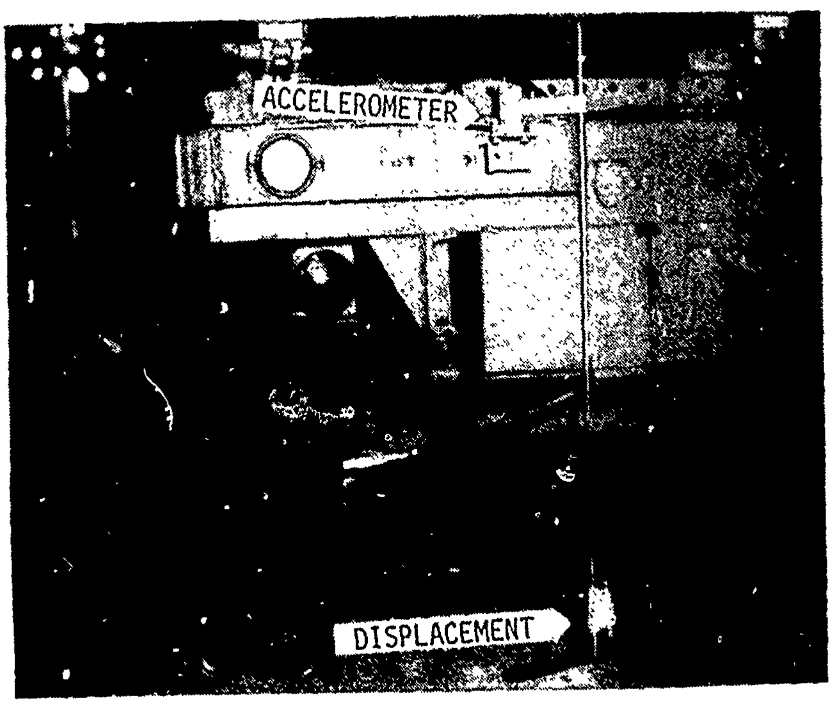


Figure 15. Transducer Location and Mounting Fixtures

1 Hertz increments to 20 Hertz.. The force input was adjusted at each increment of frequency to the required input, then an event marker switch was pressed to mark the data point on the magnetic tape. The tension load in each chain was computed using the preload as the base to determine the tension load caused by vibration. Tension load was normalized, divided by peak force input, to clearly illustrate the effect of frequency. A typical plot of normalized tension load versus frequency is shown in figure 16. Plots of all tension load data, peak acceleration data, and peak displacement data on tests of the unshored and axle shored trailer are included in appendix A.

With the loaded trailer tied down on the table, the natural frequency of the test assembly was measured by manually exciting the table supported by the truck tire inner tubes and recording the input acceleration versus time. This natural frequency measured 2.1 Hertz.

The unshored trailer was tested first. It was not possible to achieve the 3000-pound peak force input at 2 or 3 Hertz; the sine wave was quite distorted at these frequencies, as well as at 4 and 7 Hertz. Force input wave forms from the unshored and axle shored tests are shown in figures 17 through 21 for comparison. Beats (periodic amplitude changes) on the input wave form were noted at most frequencies and were quite apparent at 17 through 20 Hertz unshored. This was attributed to inadequate power in the hydraulic system to overcome mechanical feedback from the test assembly. Considerable rattling of the tie-down chains was noted, particularly at frequencies of 7 through 11 Hertz and 17 through 20 Hertz, but no severe impacting of the tiedown chains was observed. No appreciable flexing of the trailer deck was observed, but there was appreciable flexing of the MHU-71/E Rails and the MHU-69A/E Cradles, most severe at 10 and 11 Hertz.

The trailer was then tested with the AFATL-designed jack stands on both axles as shoring, as shown in figure 3. No severe impacting of the tiedown chains was observed, and there was no appreciable flexing of the trailer deck. There was appreciable flexing of the MHU-71/E Rails and the MHU-69A/E Cradles.

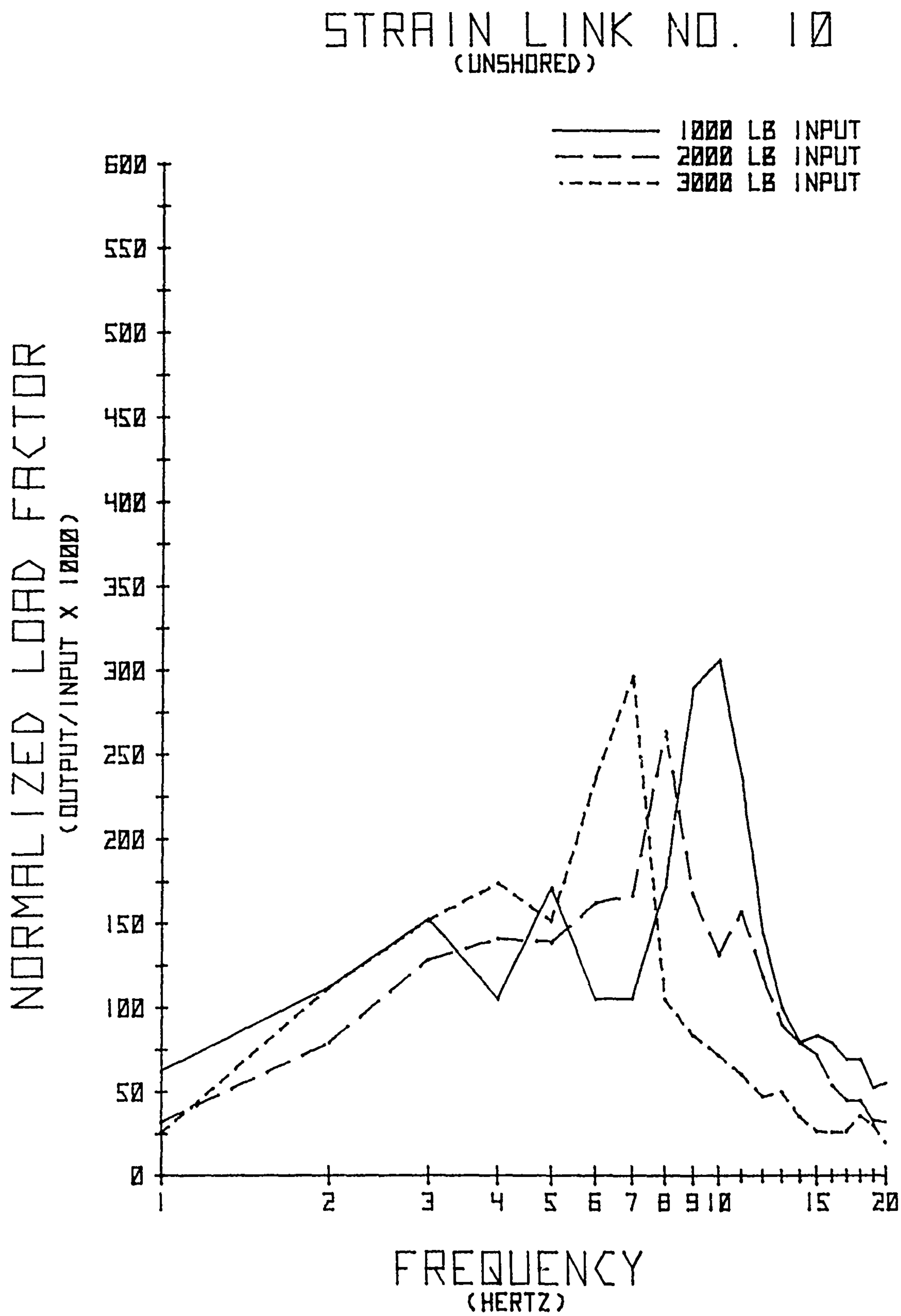
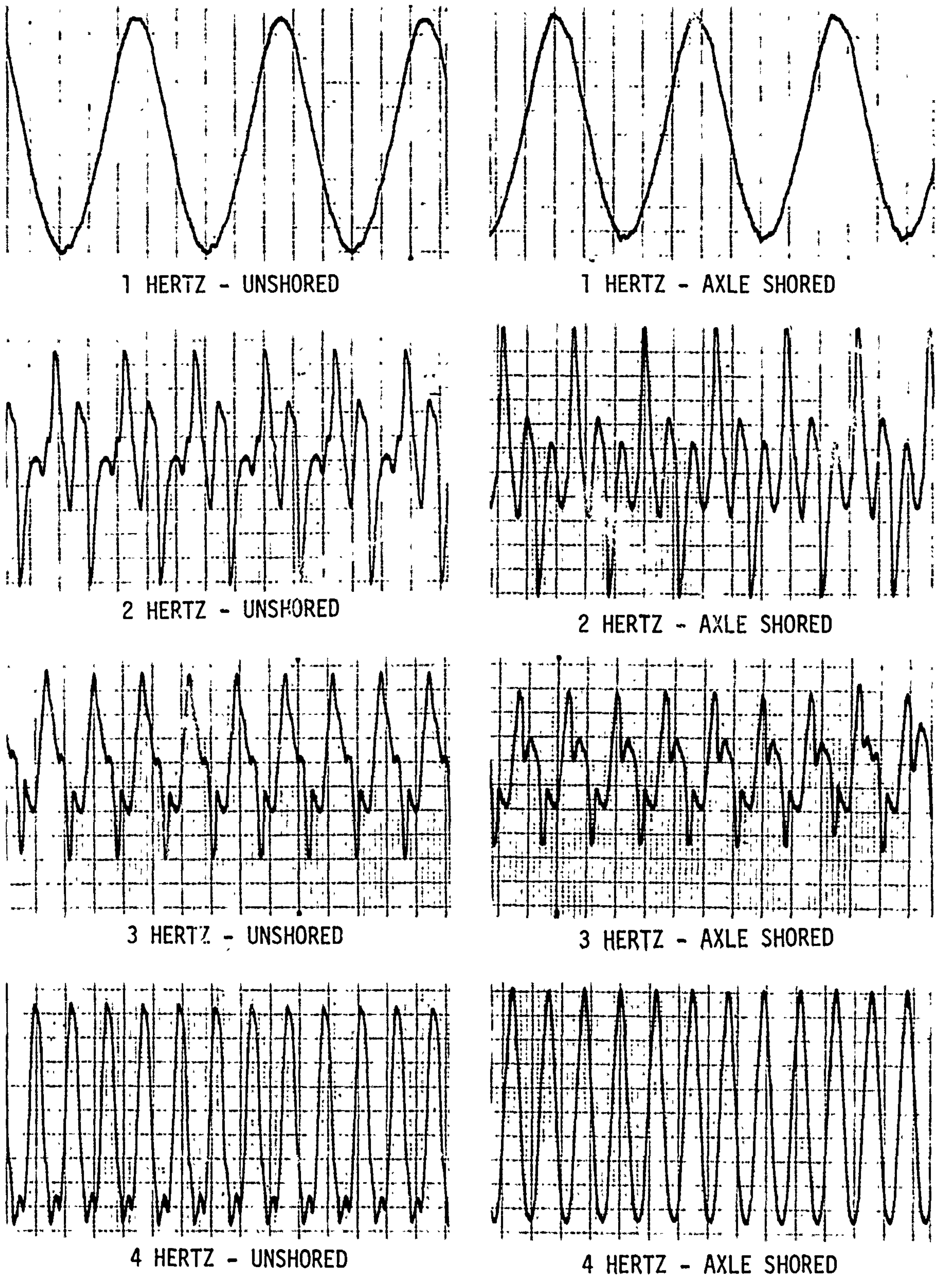
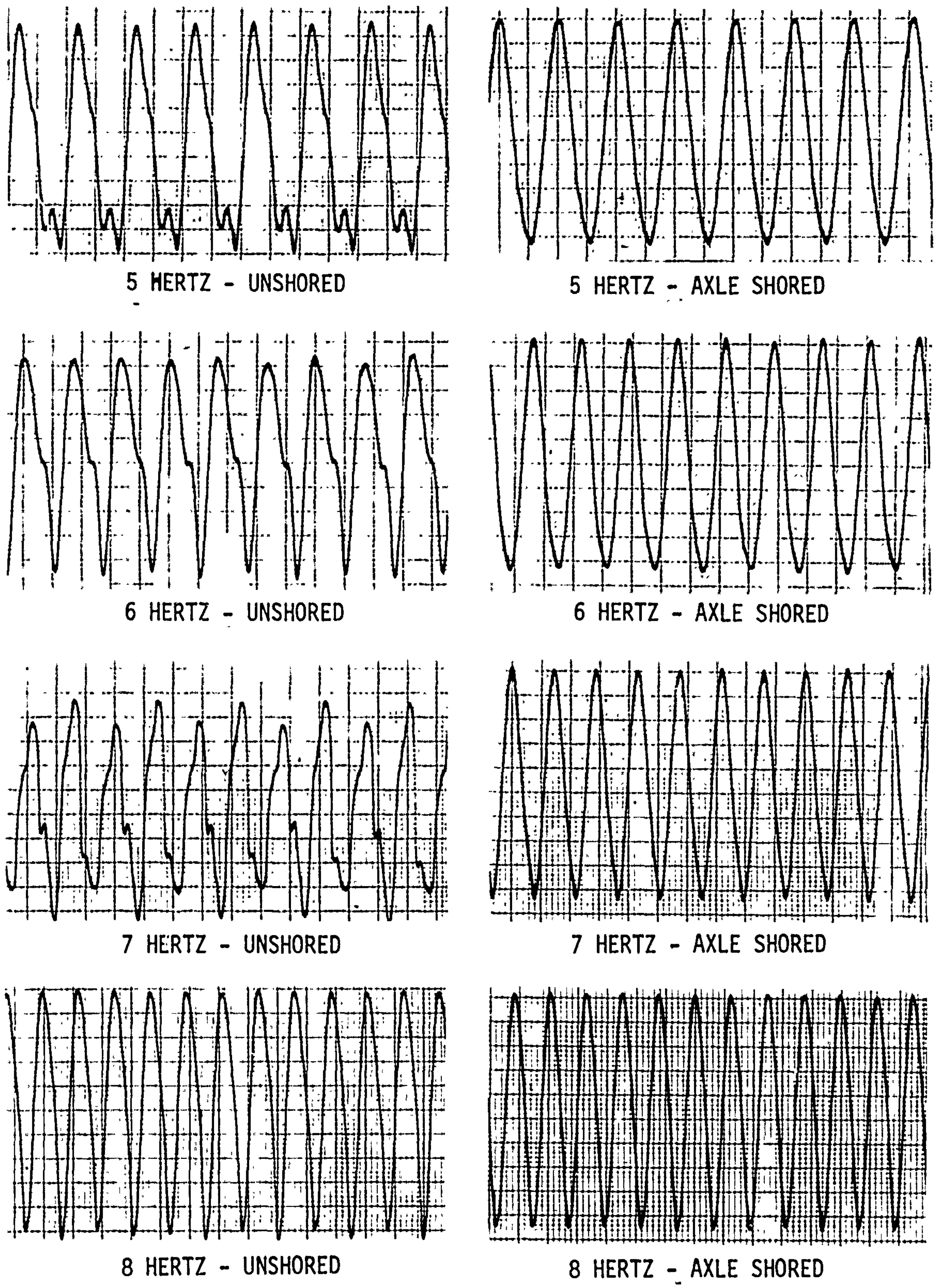


Figure 16. Typical Tension Load With Rail Set



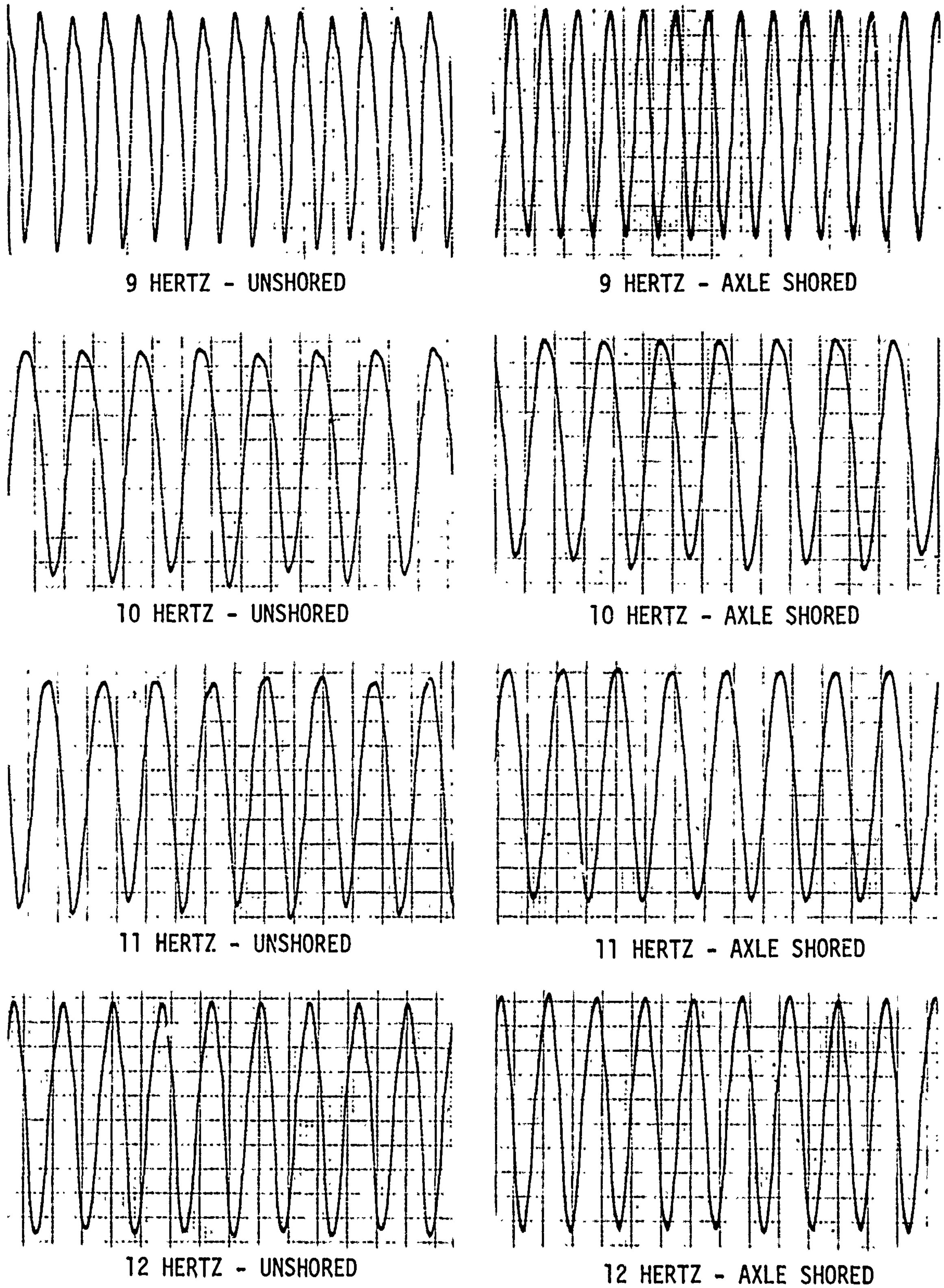
Amplitude Scale: 1 Div. = 120 Pounds

Figure 17. Input Wave Forms 1 to 4 Hertz



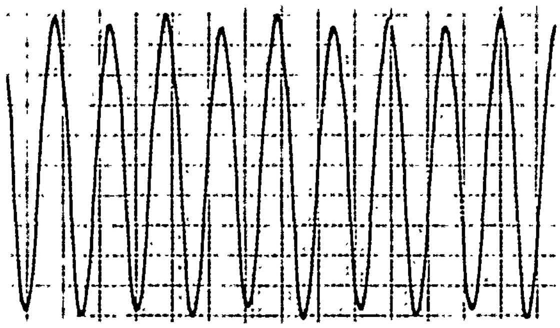
Amplitude Scale: 1 Div. = 120 Pounds

Figure 18. Input Wave Forms 5 to 8 Hertz

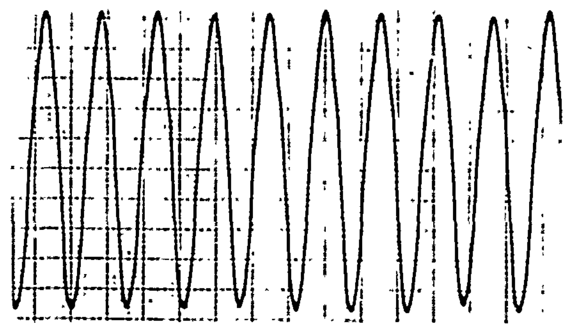


Amplitude Scale: 1 Div. = 120 Pounds

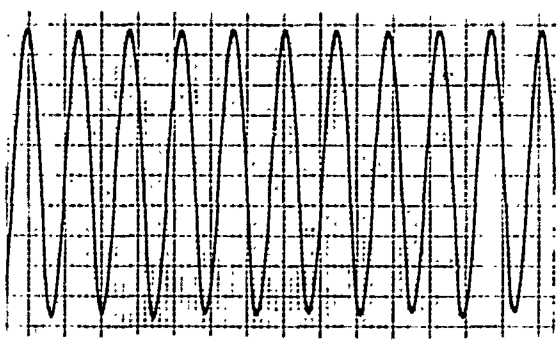
Figure 19. Input Wave Forms 9 to 12 Hertz



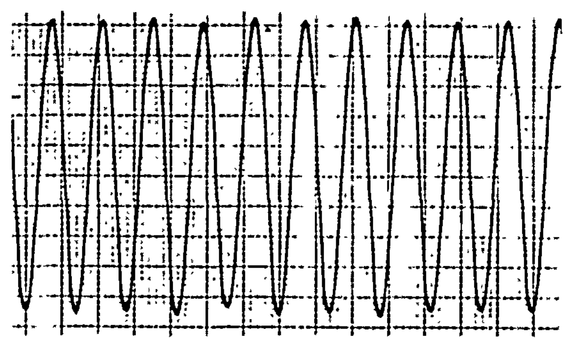
13 HERTZ - UNSHORED



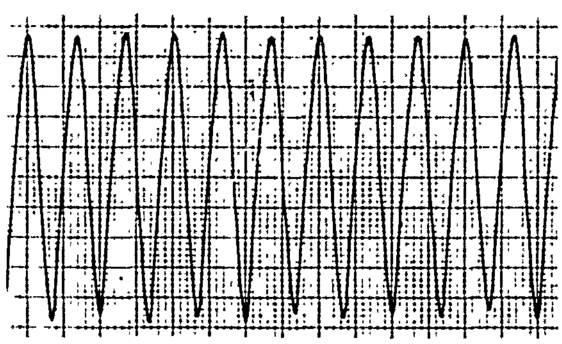
13 HERTZ - AXLE SHORED



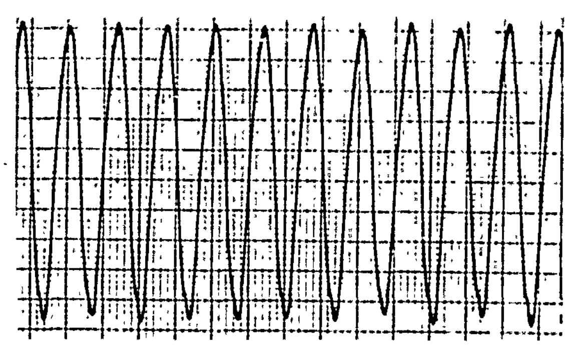
14 HERTZ - UNSHORED



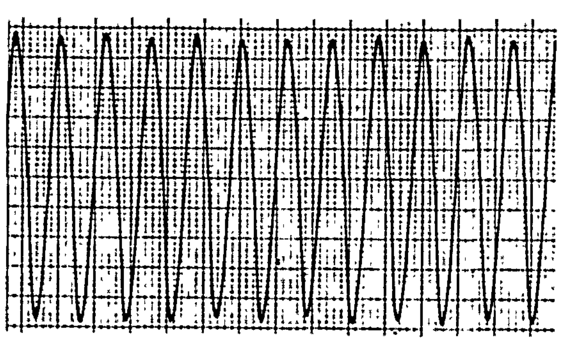
14 HERTZ - AXLE SHORED



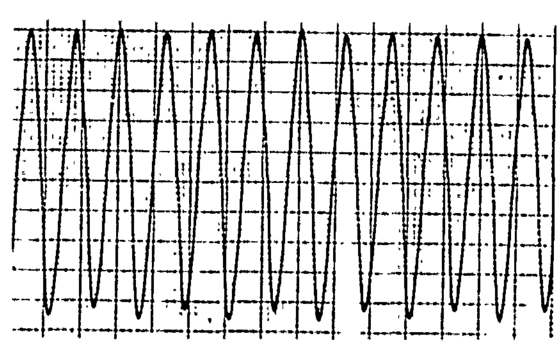
15 HERTZ - UNSHORED



15 HERTZ - AXLE SHORED



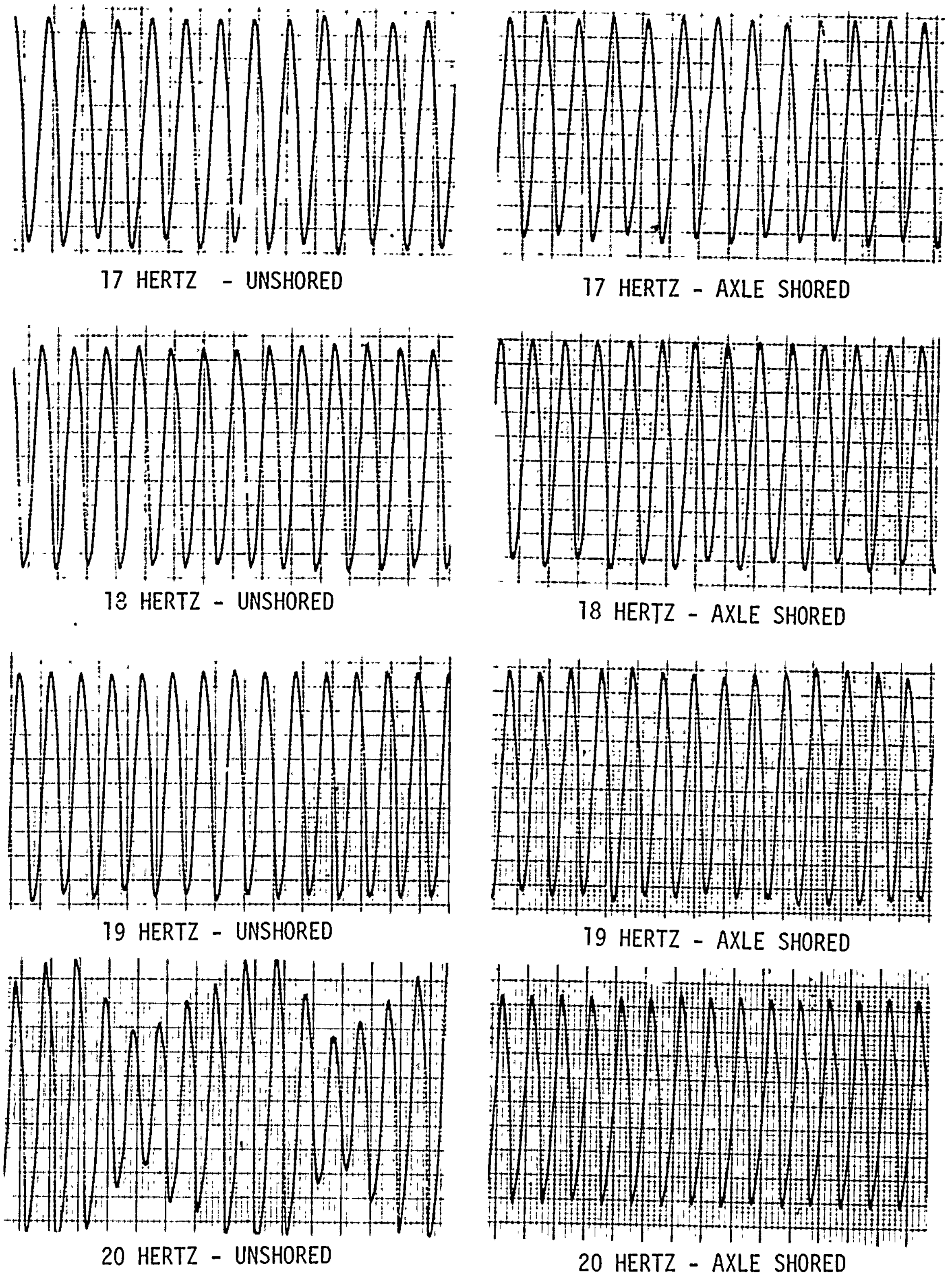
16 HERTZ - UNSHORED



16 HERTZ - AXLE SHORED

Amplitude Scale: 1 Div. = 120 Pounds

Figure 20. Input Wave Forms 13 to 16



Amplitude Scale: 1 Div. = 120 Pounds

Figure 21. Input Wave Forms 17 to 20 Hertz

Motion pictures at 64 frames per second were taken on these tests and viewed by the AFWL Project Monitor and the AFSWC Test Director. Viewed at the slowed rate, no appreciable flexing of the trailer deck was observed. Appreciable flexing of one MHU-71/E Rail was observed but the motion picture camera was not oriented to show the other three rails or the MHU-69A/E Cradles.

For comparison the acceleration data at the 3000-pound force input at each location from the unshored and axle shored tests were plotted on the same graph (shown in figures 22 and 23). Data from strain link No. 1 were plotted in the same manner (figure 24). These plots show that the peak acceleration on the trailer deck is approximately the same with axle shoring as without, but that axle shoring causes peak acceleration to occur at a higher frequency.

Similar tests of the axle shored MHU-12/M Trailer, loaded with two BDU-8 Weapon Shapes on chocks, indicated that appreciable flexing of the trailer deck occurred at some frequencies and that a preferred location for shoring was under the center structural tube (ref. 3). Also it was noted that flexing of the MHU-71/E Rails and MHU-69A/E Cradles absorbed considerable energy which would otherwise be transmitted to the trailer deck. As a result of this information, ADTC requested dynamic testing of the MHU-141/M Trailer, loaded with the two simulated missile shapes on chocks, unshored and with various shoring methods.

For these tests the MHU-71/E Rail Sets were removed and the missile shapes mounted on chocks and tied down with chains and MB-1 tiedown devices. This test assembly mounted on the table for test is shown in figure 25. Instrumentation and control were the same as on the initial tests.

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3. Gray, Grant W., Static and Dynamic Test of an Axle Shored MHU-12/M Trailer, Technical Report AFSWC-TR-75-23, Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, to be published.

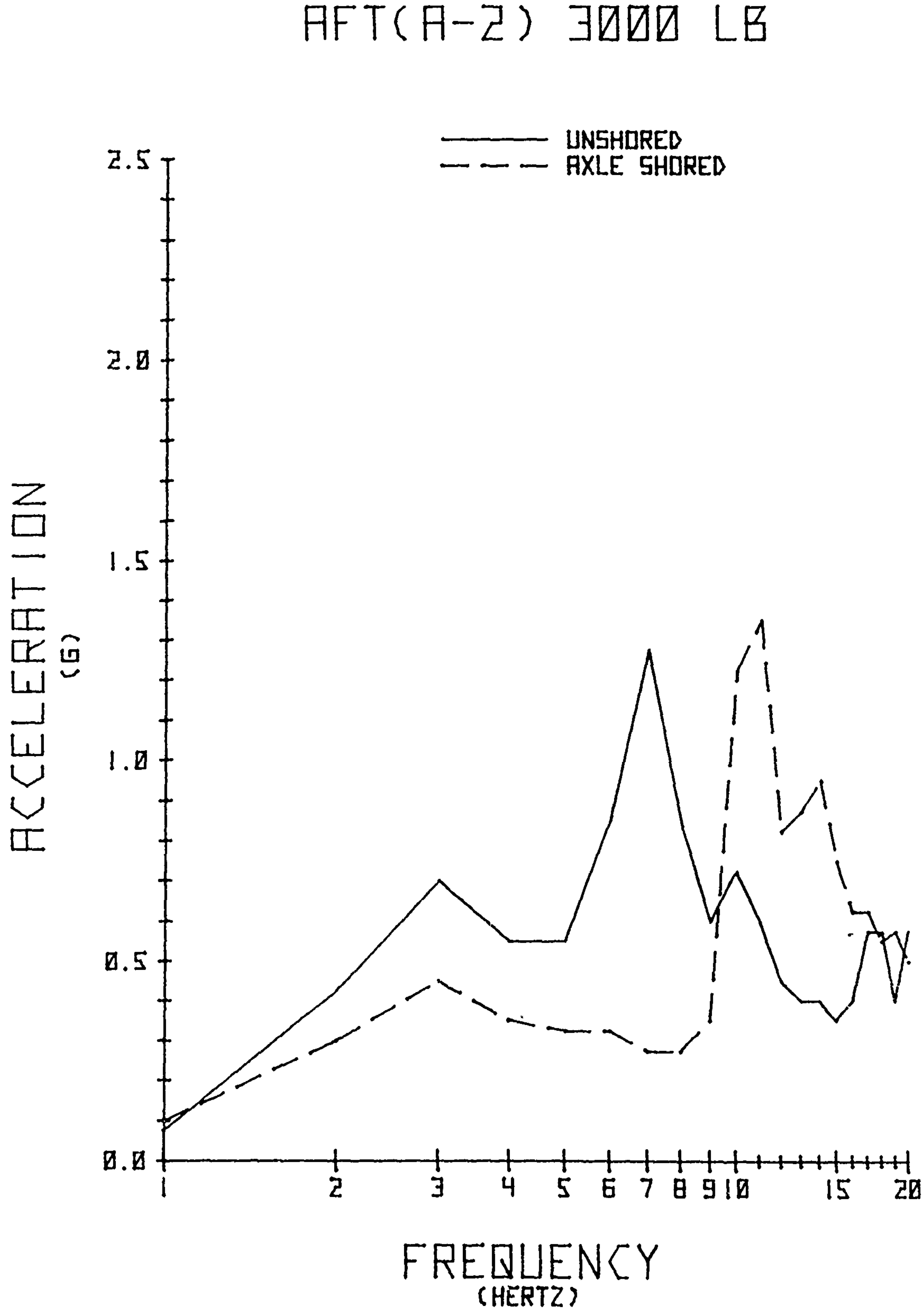


Figure 22. Aft Acceleration With Rail Set

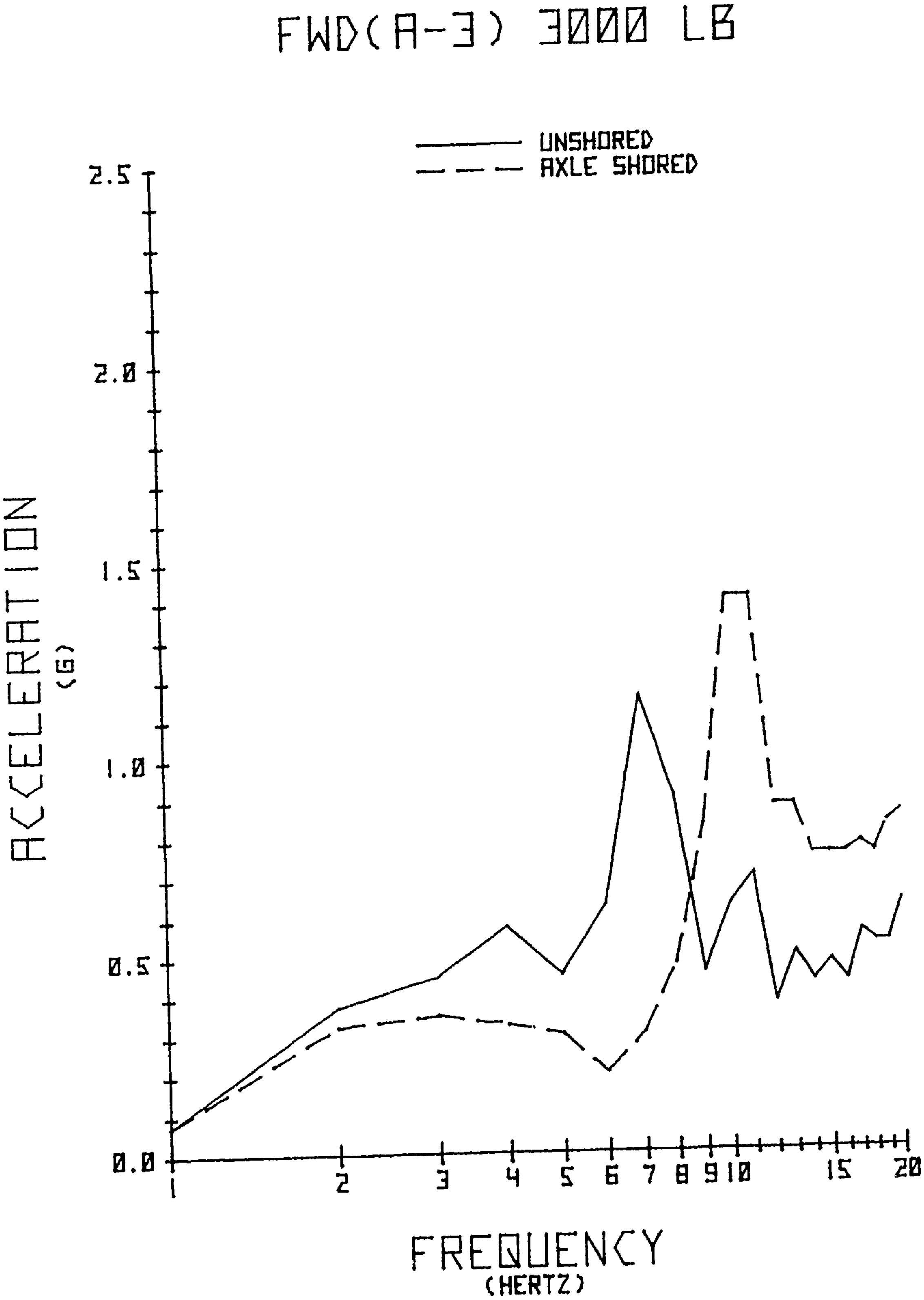


Figure 23. Forward Acceleration With Rail Set

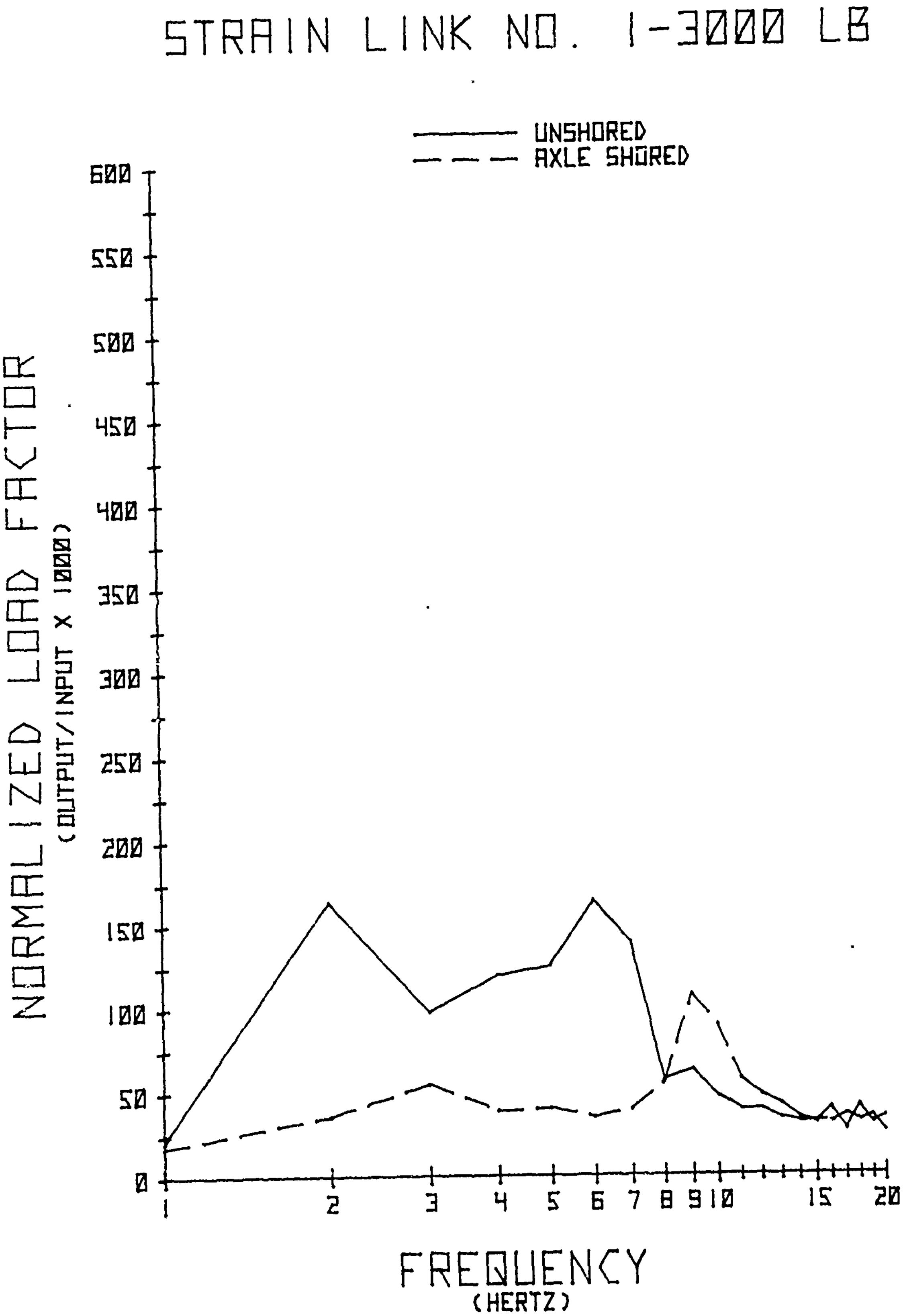


Figure 24. Tension Load With Rail Set

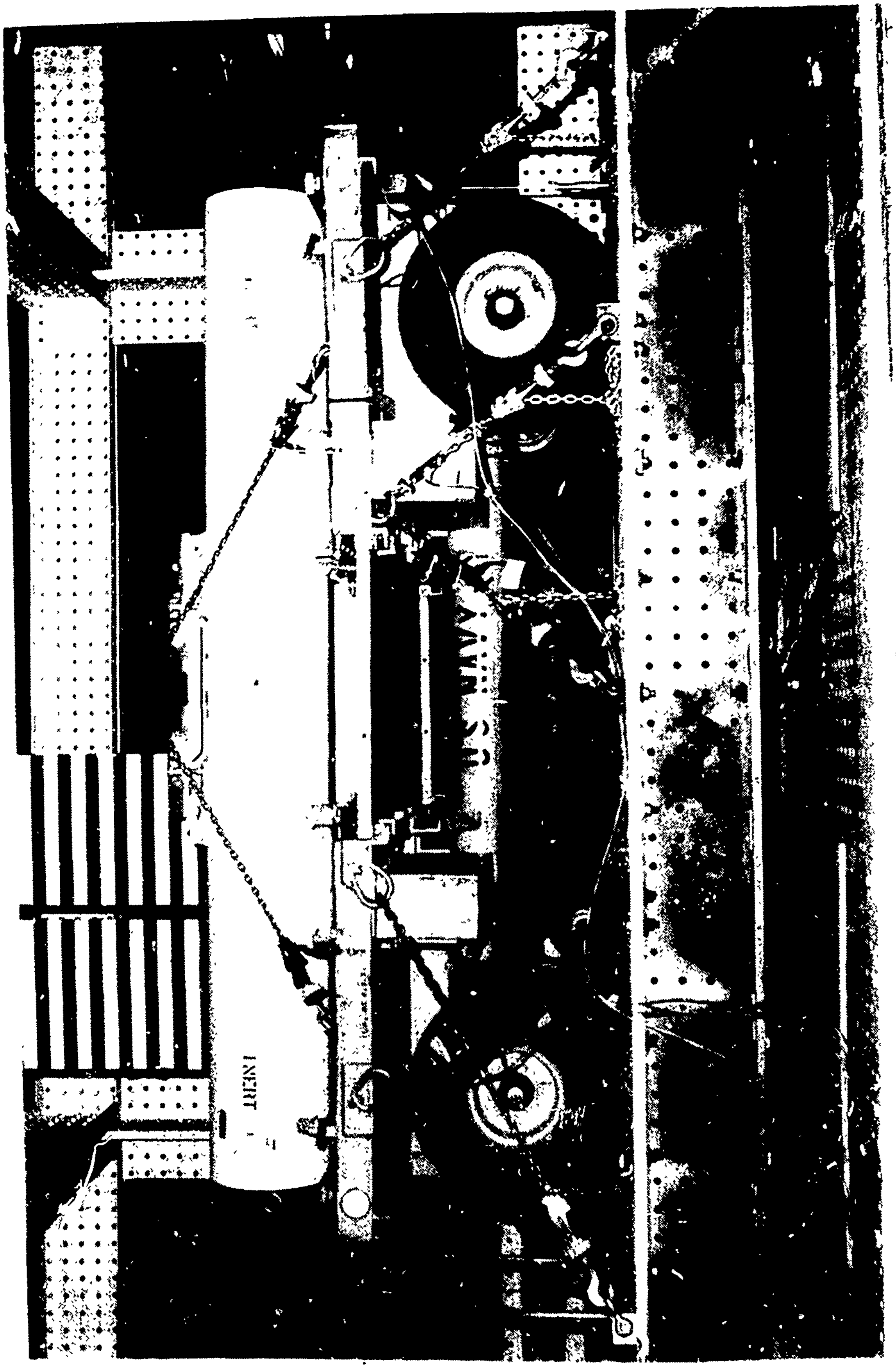


Figure 25. Dynamic Test Assembly Without Rail Set

The unshored configuration was tested first, then the axle shored configuration using the AFATL-designed jack stands was tested. Response of the trailer was similar to that of the initial tests. No severe impacting of chains or flexing of the trailer deck was noted. Hardwood blocks were then placed between the springs and the trailer frame, as shown in figure 26, and the test repeated with both the tires and springs removed from the spring-mass system. Again, no severe impacting of the tiedown chains was observed but there was appreciable flexing of the trailer deck. The axle and frame shoring was then removed, and shoring was placed under the center of the trailer center tube, as shown in figure 27. The test was repeated with little rattling of the tiedown chains and with no apparent flexing of the trailer deck.

For comparison of shoring methods, the acceleration data at the 3000-pound force input at each location for the unshored and the three different shoring methods were plotted on the same graph (figures 28, 29, and 30). Data from strain link No. 1 were plotted in the same manner (figure 31). These plots show the center tube shoring to be the most effective at frequencies below 20 Hz. Plots of all data from these tests are included in appendix B.

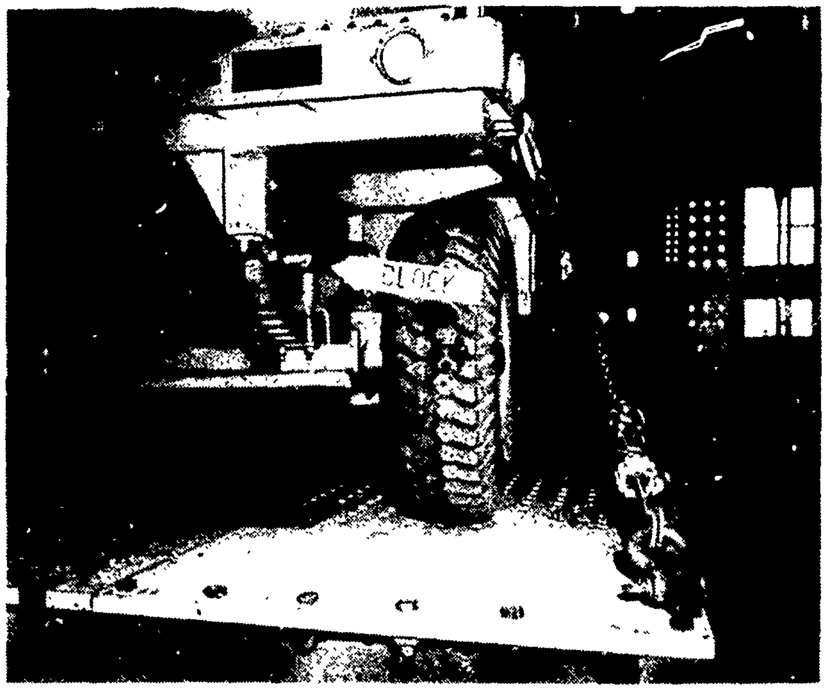


Figure 26. Frame Shoring

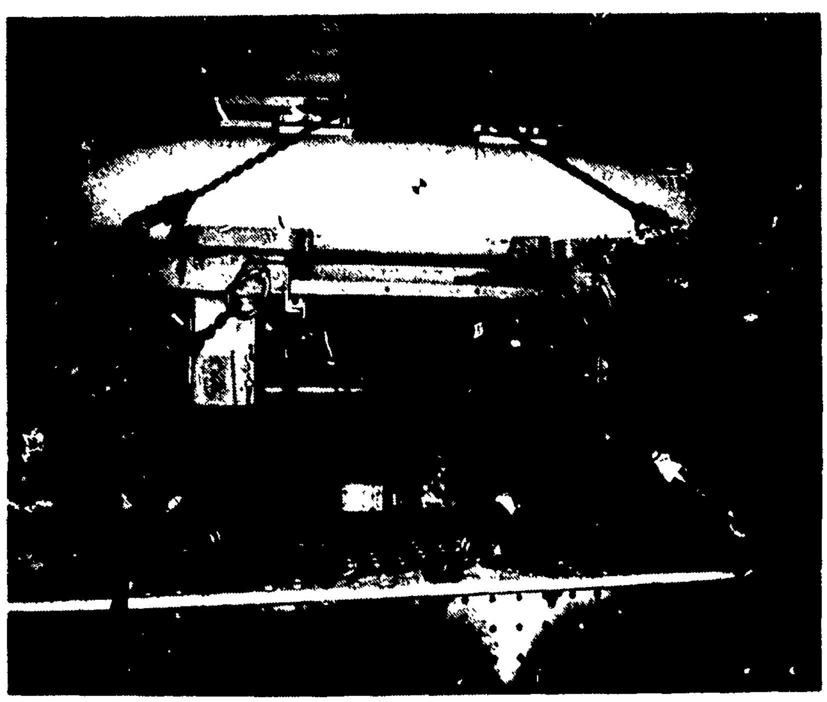


Figure 27. Tube Shoring

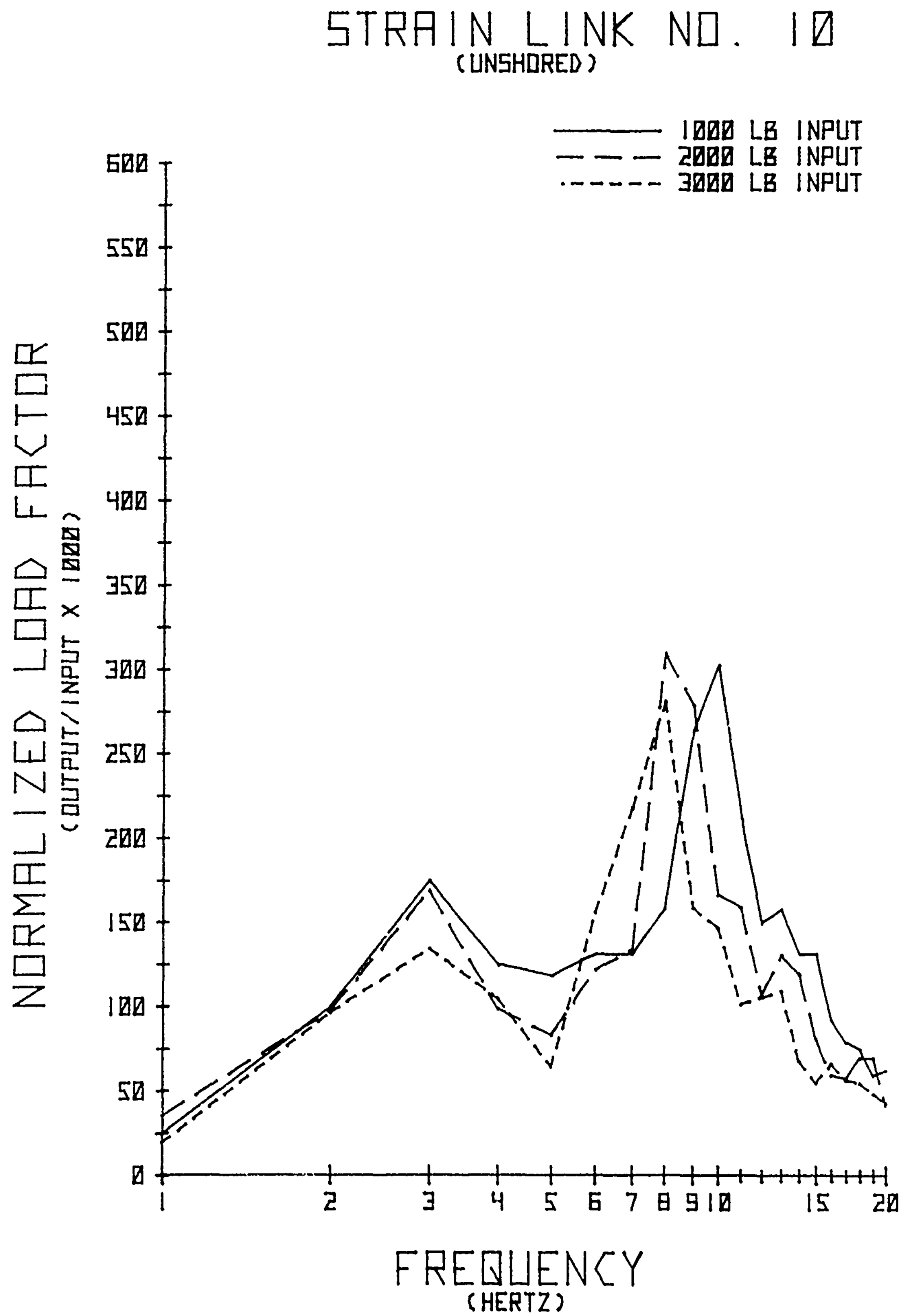


Figure 28. Typical Tension Load Without Rail Set

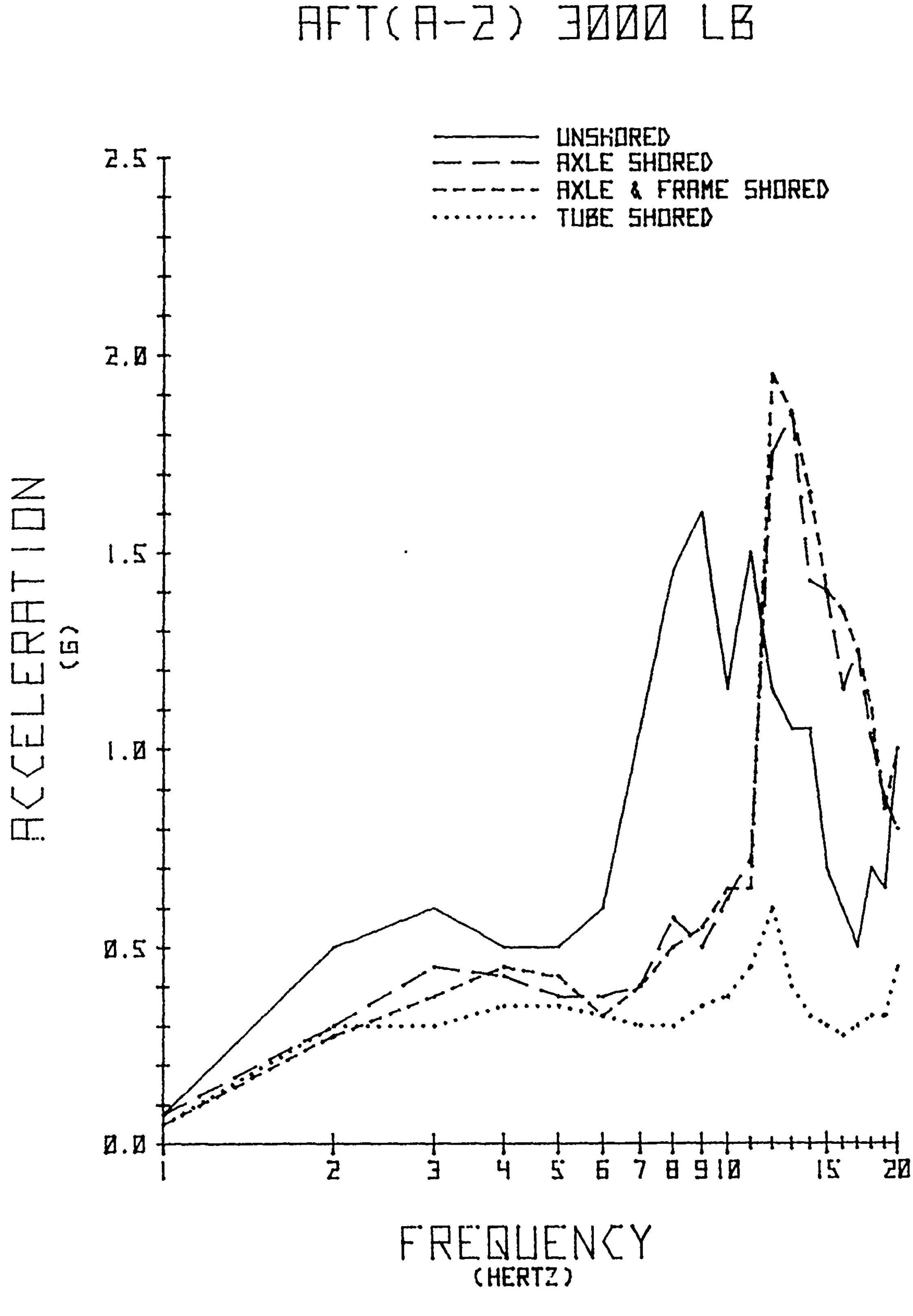


Figure 29. Aft Acceleration Without Rail Set

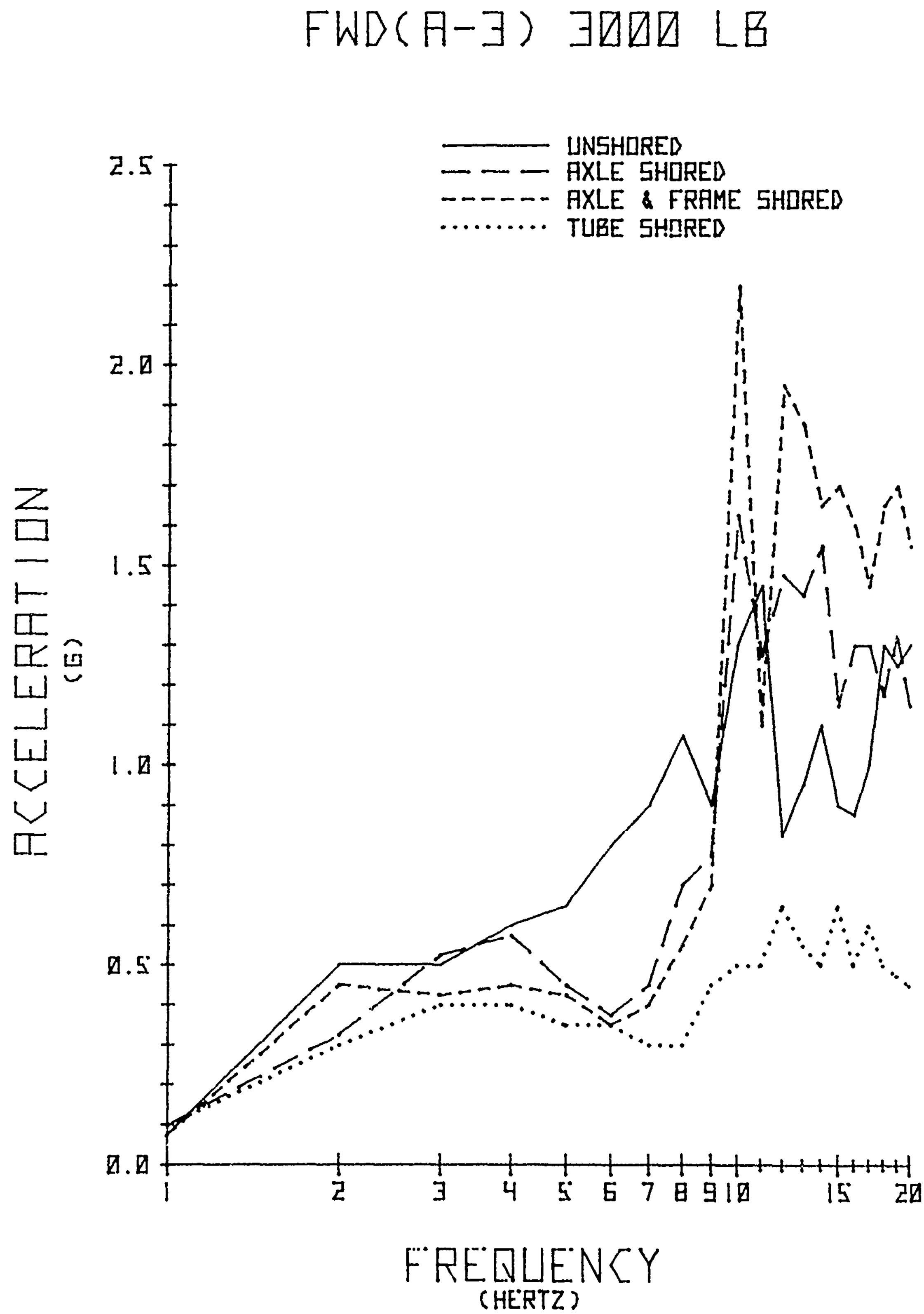


Figure 30. Forward Acceleration Without Rail Set

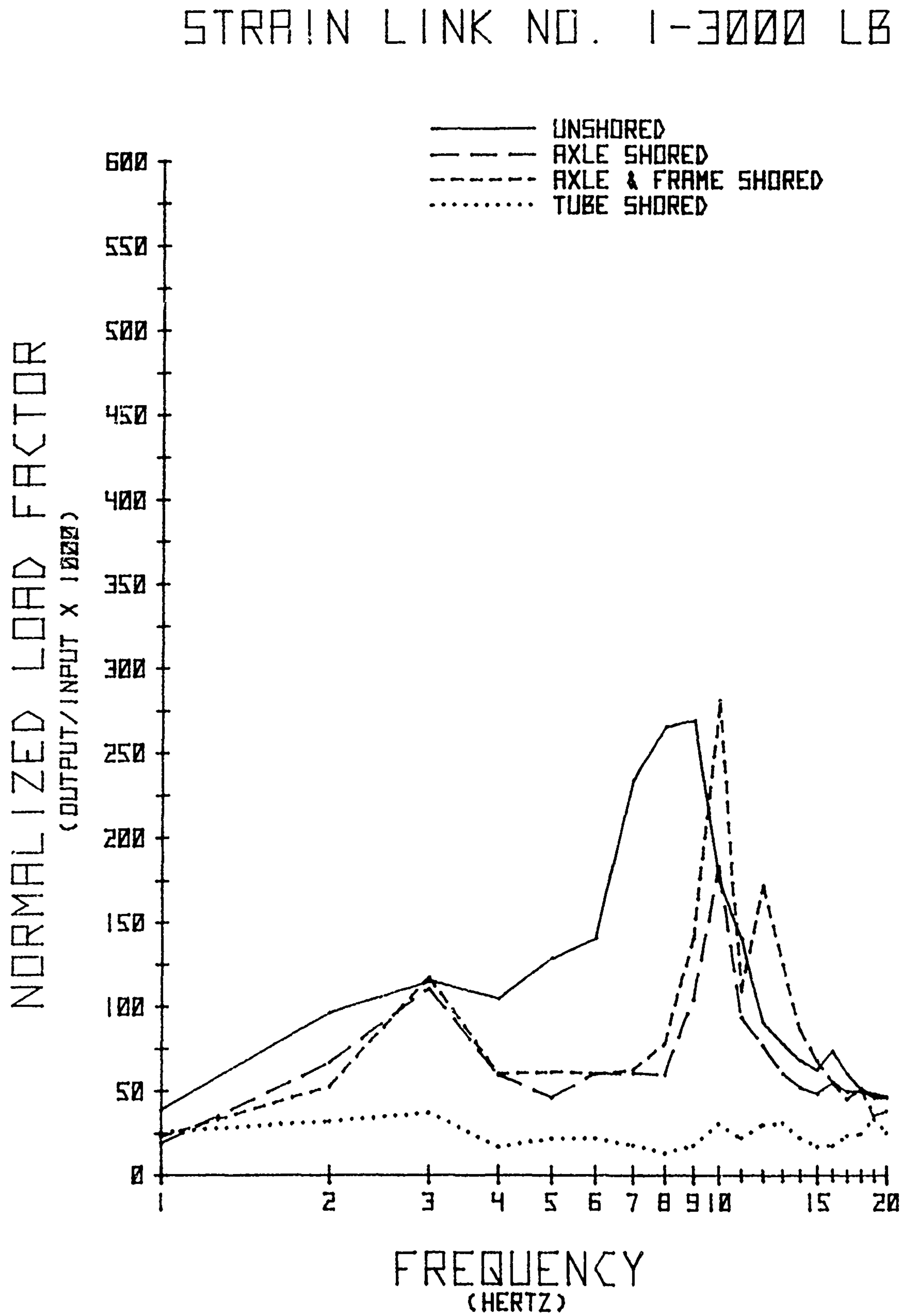


Figure 31. Tension Load Without Rail Set

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

a. The AFATL-designed jack stands tested are satisfactory as axle shoring for the loaded MHU-141/M Trailer.

b. Proper orientation of some tie rings is necessary for safe tiedown for air transport of the loaded MHU-141/M Trailer.

c. There is no severe impact loading of tiedown chains in the frequency range of 1 to 20 Hertz at inputs up to 3000 pounds peak force vertically on the loaded MHU-141/M Trailer unshored or shored.

d. Appreciable flexing of the MHU-71/E Rail Set and the MHU-69A/E Cradles loaded with SRAM missile shapes occurs at some frequencies in the 1 to 20 Hertz range.

e. Appreciable flexing of the MHU-141/M Trailer deck occurs at some frequencies in the 1 to 20 Hertz range with the SRAM missile shapes mounted on chocks on the trailer deck rails and both frame and axle shoring.

f. Shoring under the center tube of the MHU-141/M Trailer minimizes the response of both the trailer and the tiedown chains to vibration inputs in the 1 to 20 Hertz range.

g. The loaded MHU-141/M Trailer satisfies the inertial load test criteria for air transport using the tiedown pattern and procedures outlined in this report.

2. RECOMMENDATIONS

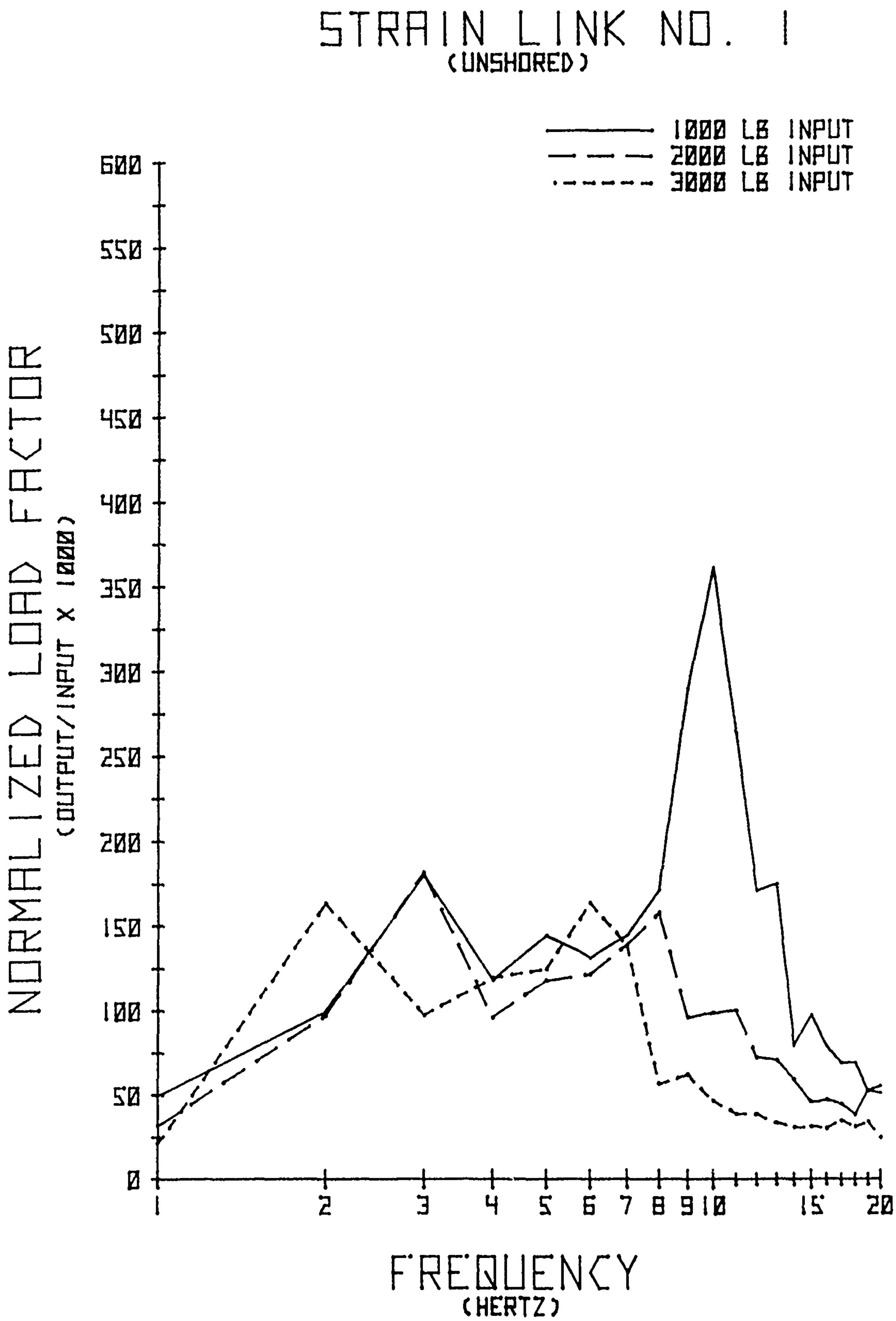
a. Tiedown procedures to insure proper orientation of tie rings should be mandatory for air transport of the loaded MHU-141/M Trailer.

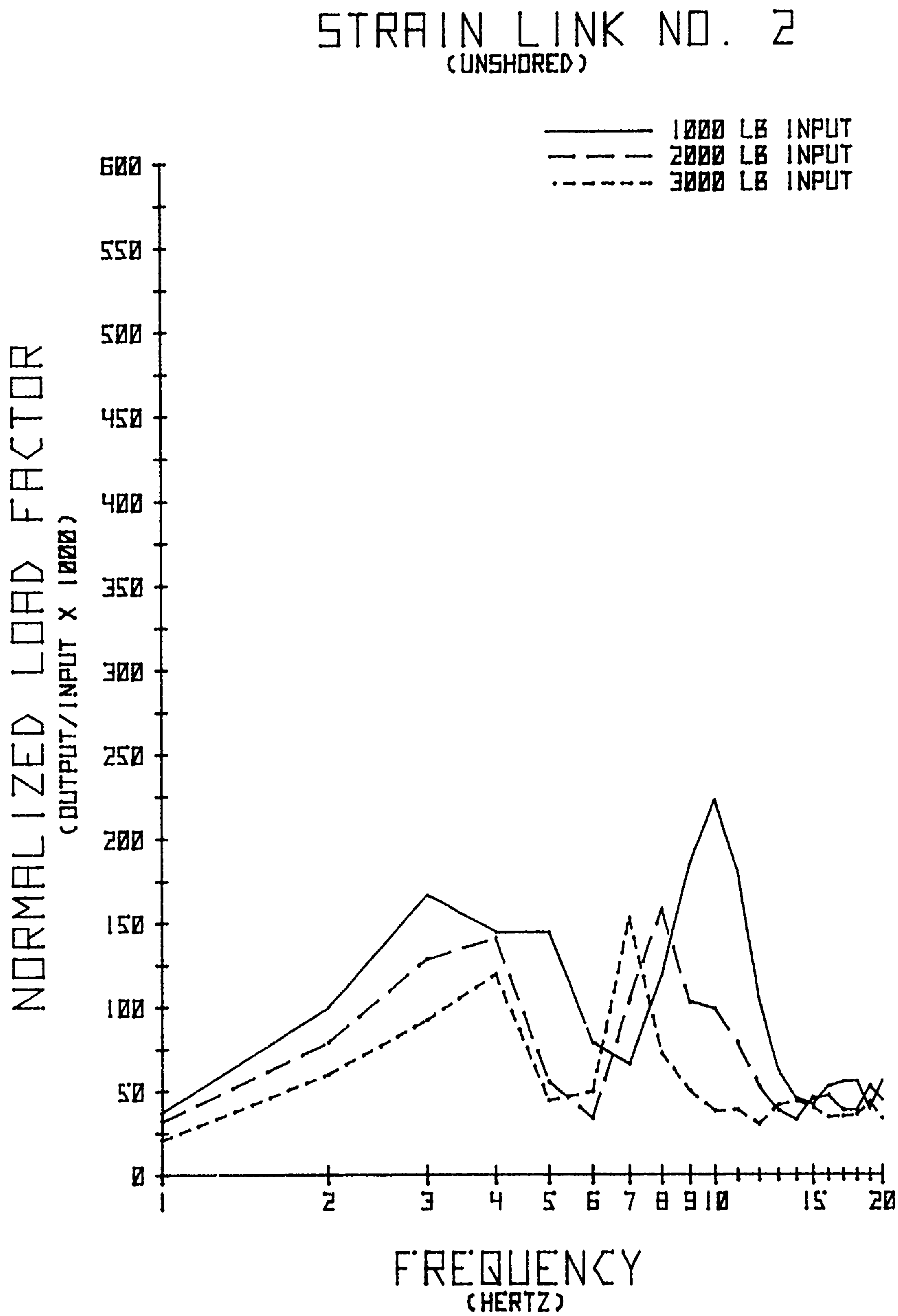
b. The tiedown pattern tested for this report should be the only one certified for air transport of the loaded MHU-141/M Trailer without additional testing.

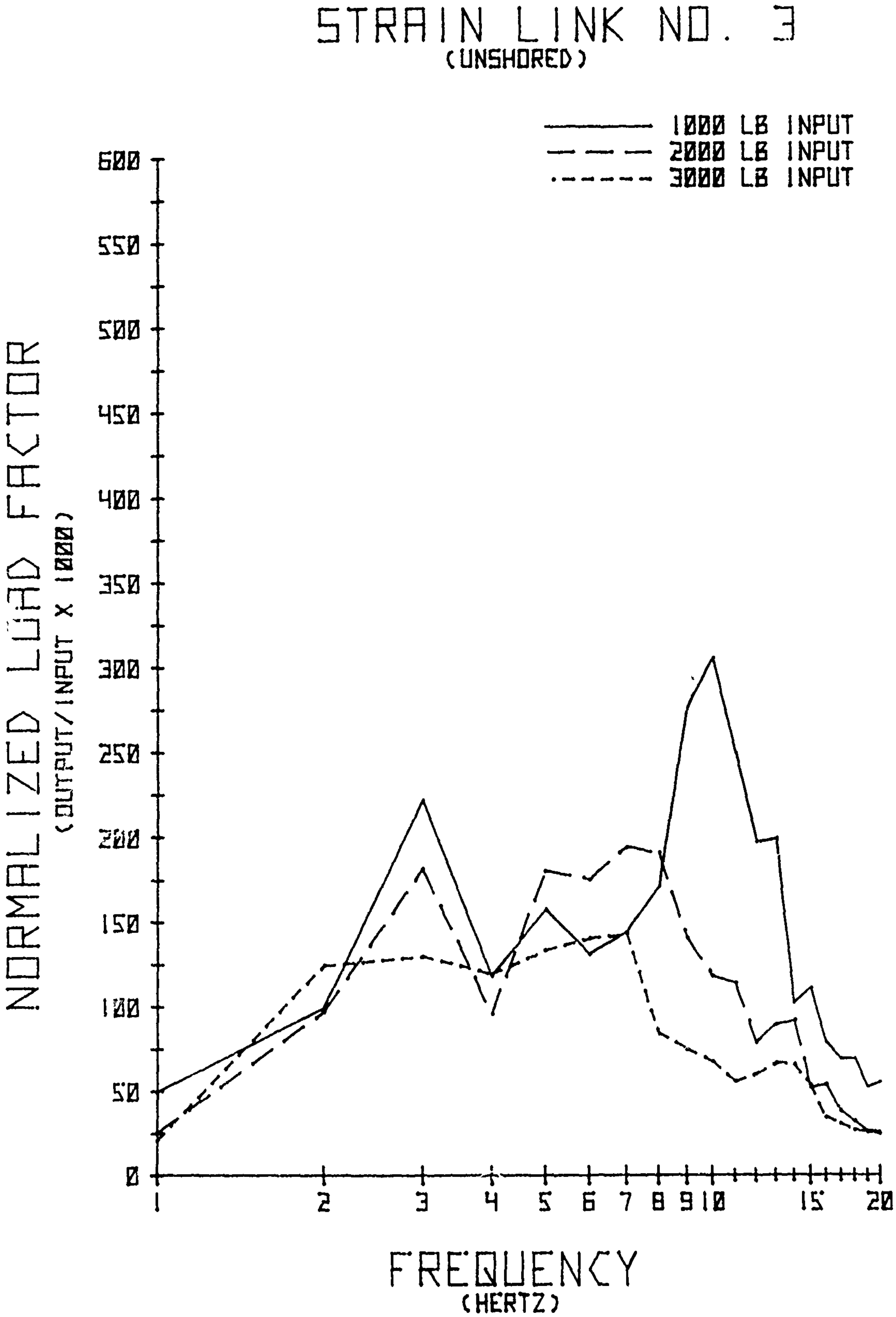
c. In the event shoring is deemed necessary for safe air transport of the loaded MHU-141/M Trailer, shoring under the center tube should be seriously considered as the preferred method.

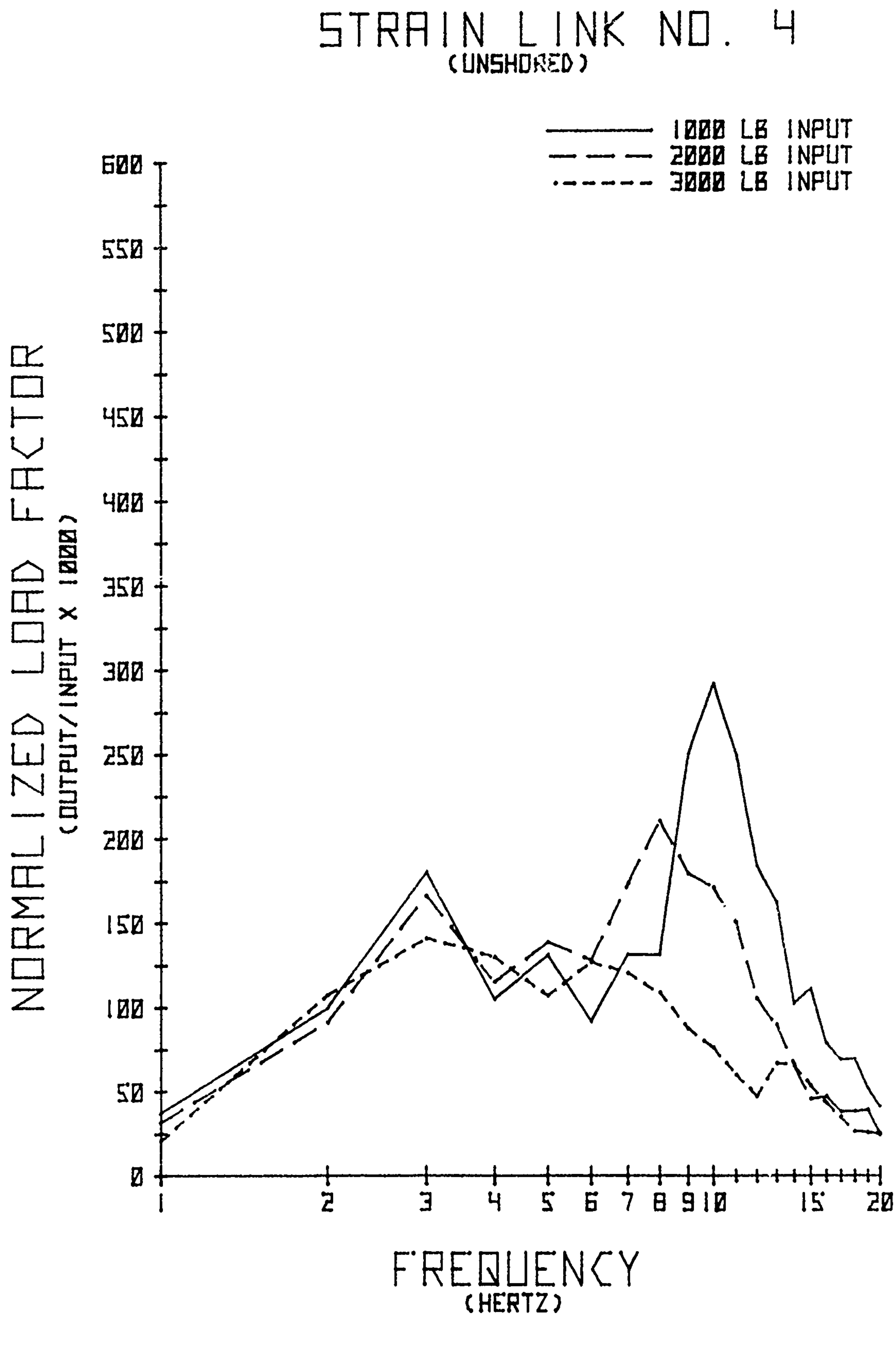
APPENDIX A

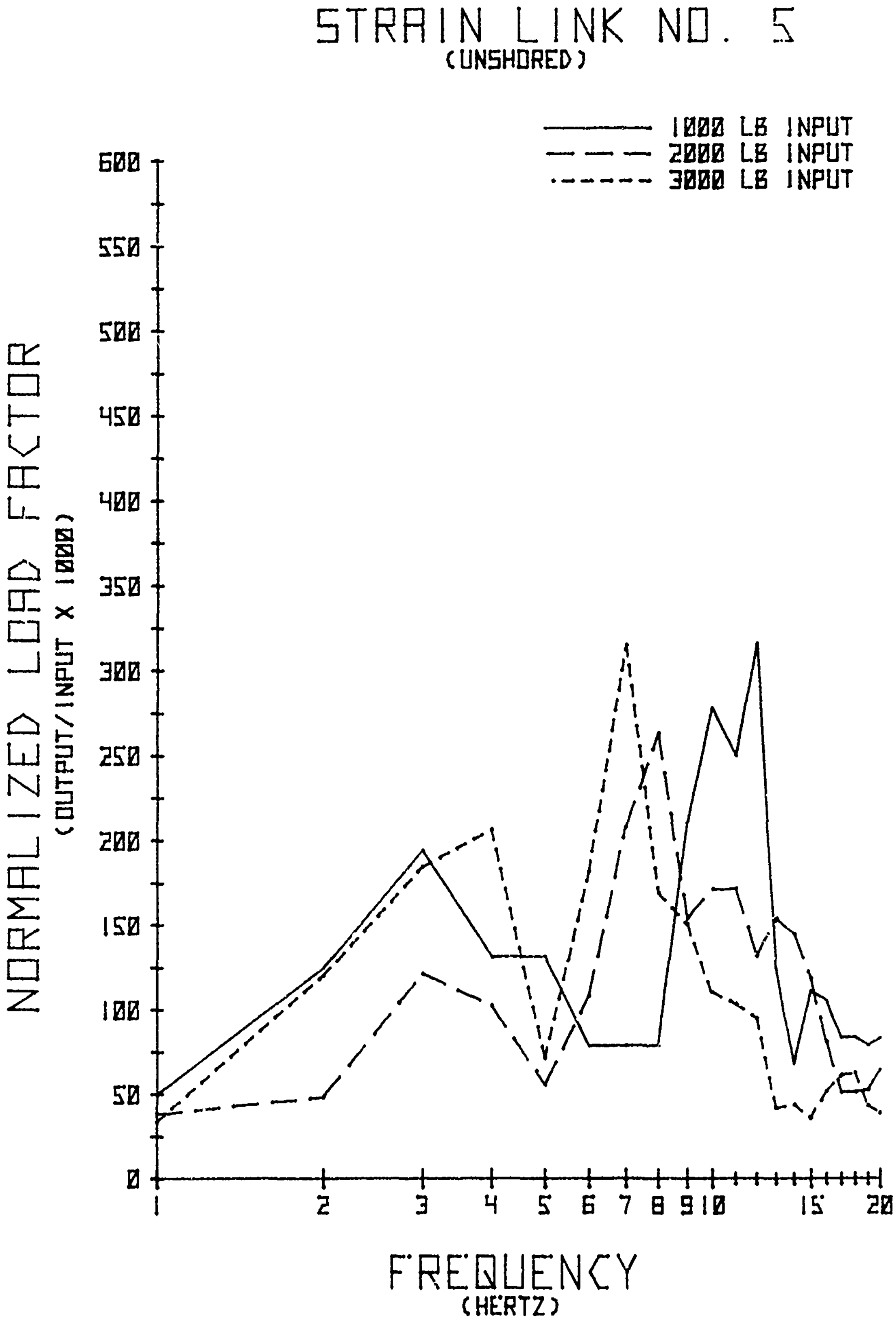
DATA PLOTS WITH MHU-71/E RAIL SET

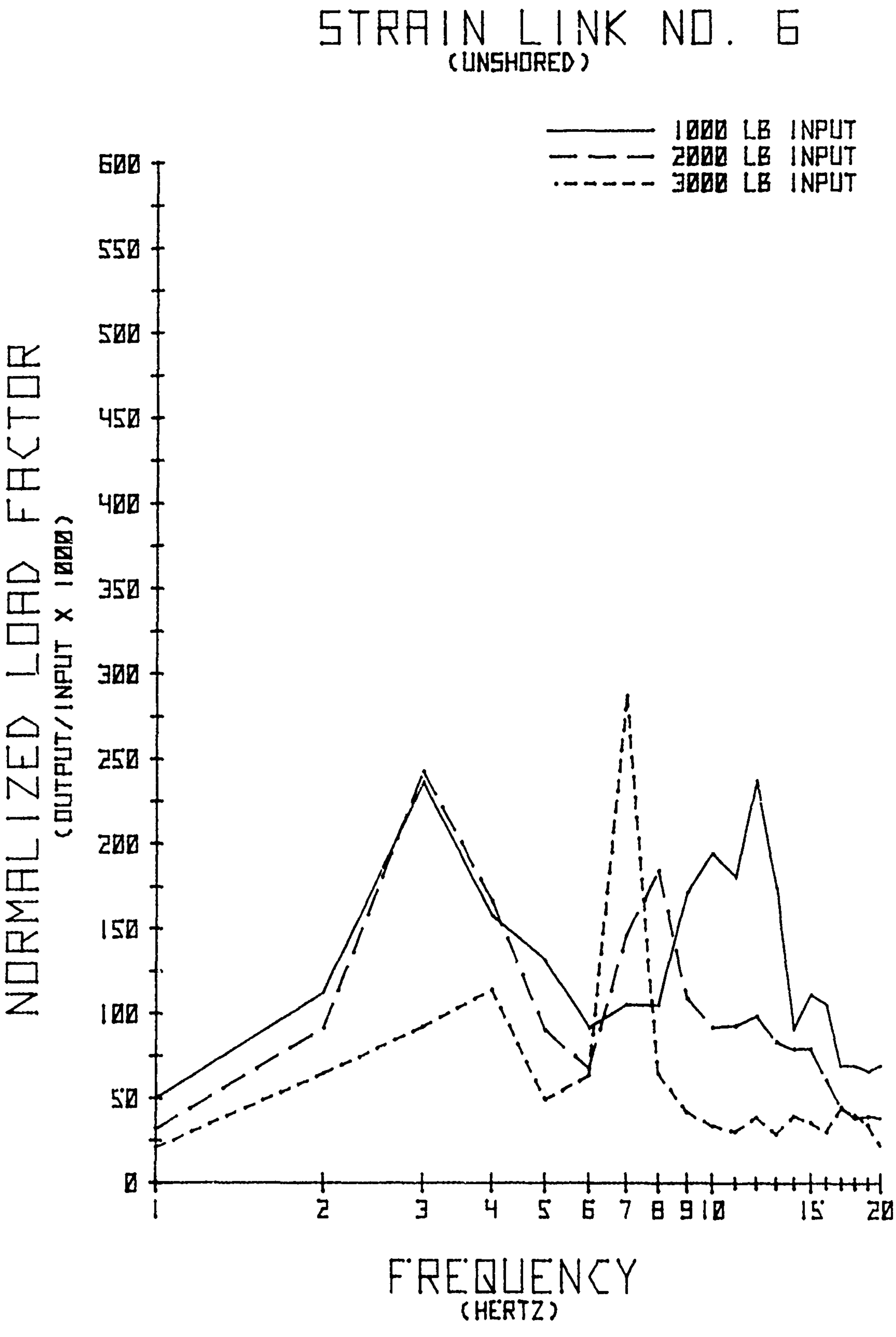

STRAIN LINK NO. 1
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

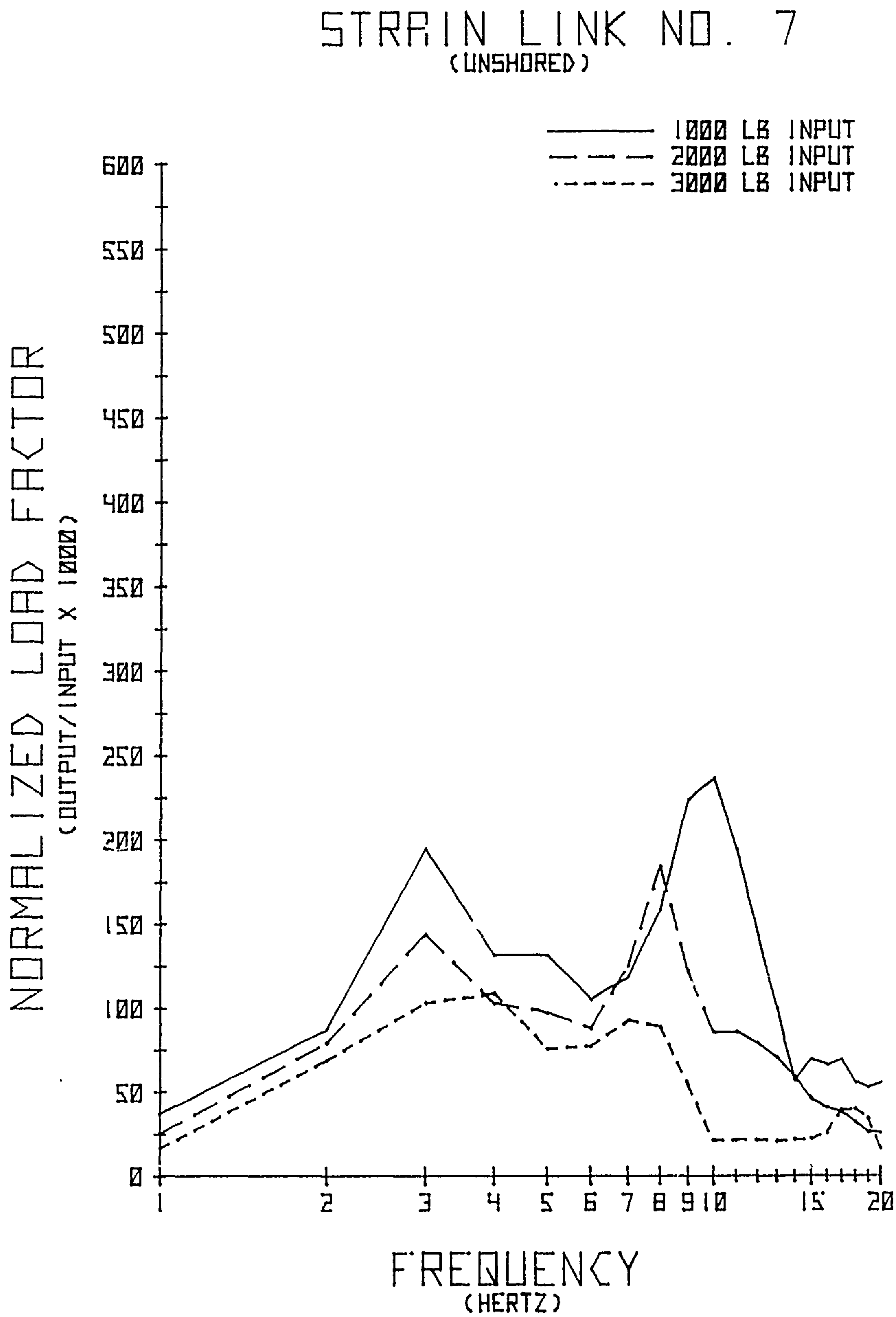

STRAIN LINK NO. 2
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

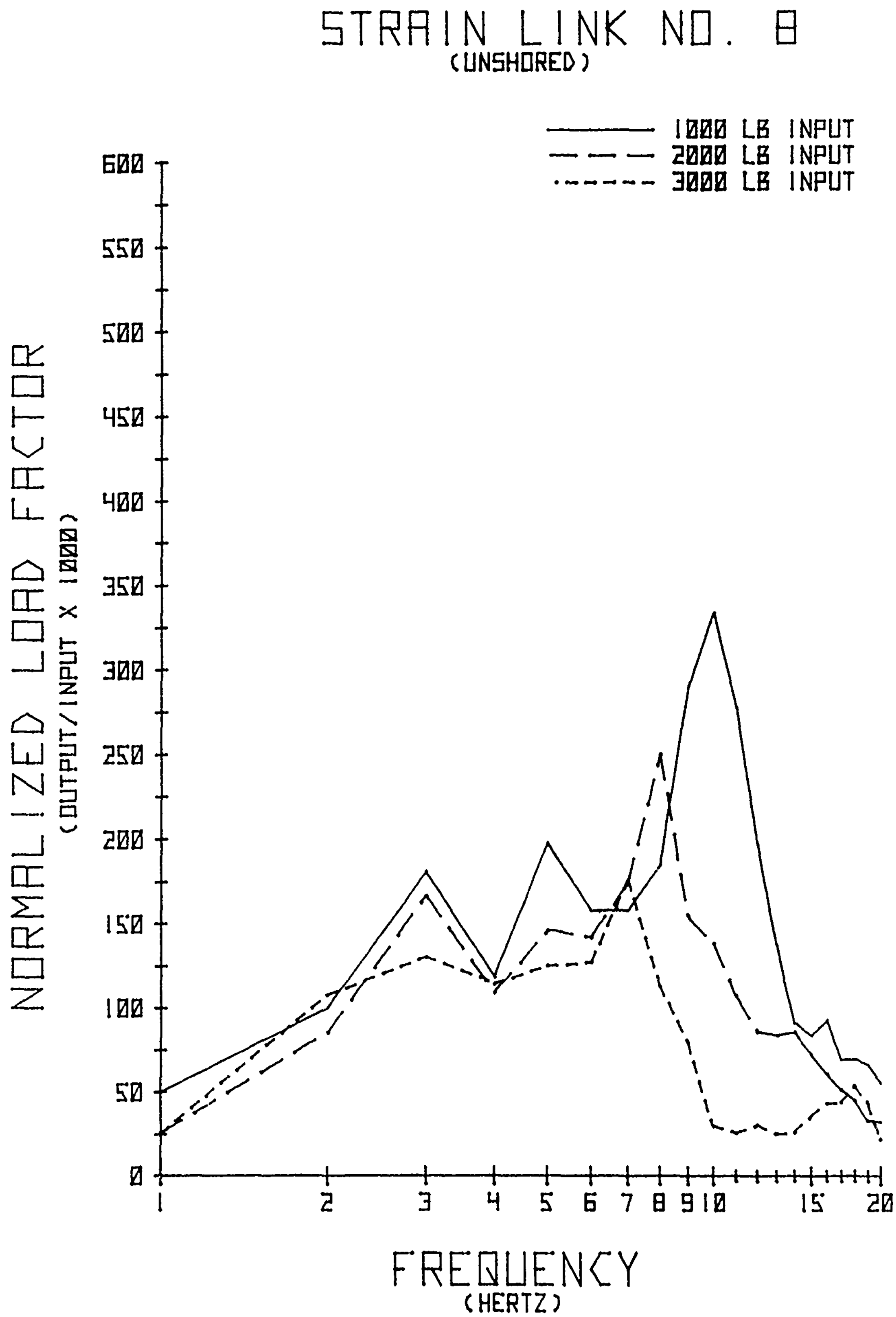

STRAIN LINK NO. 3
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

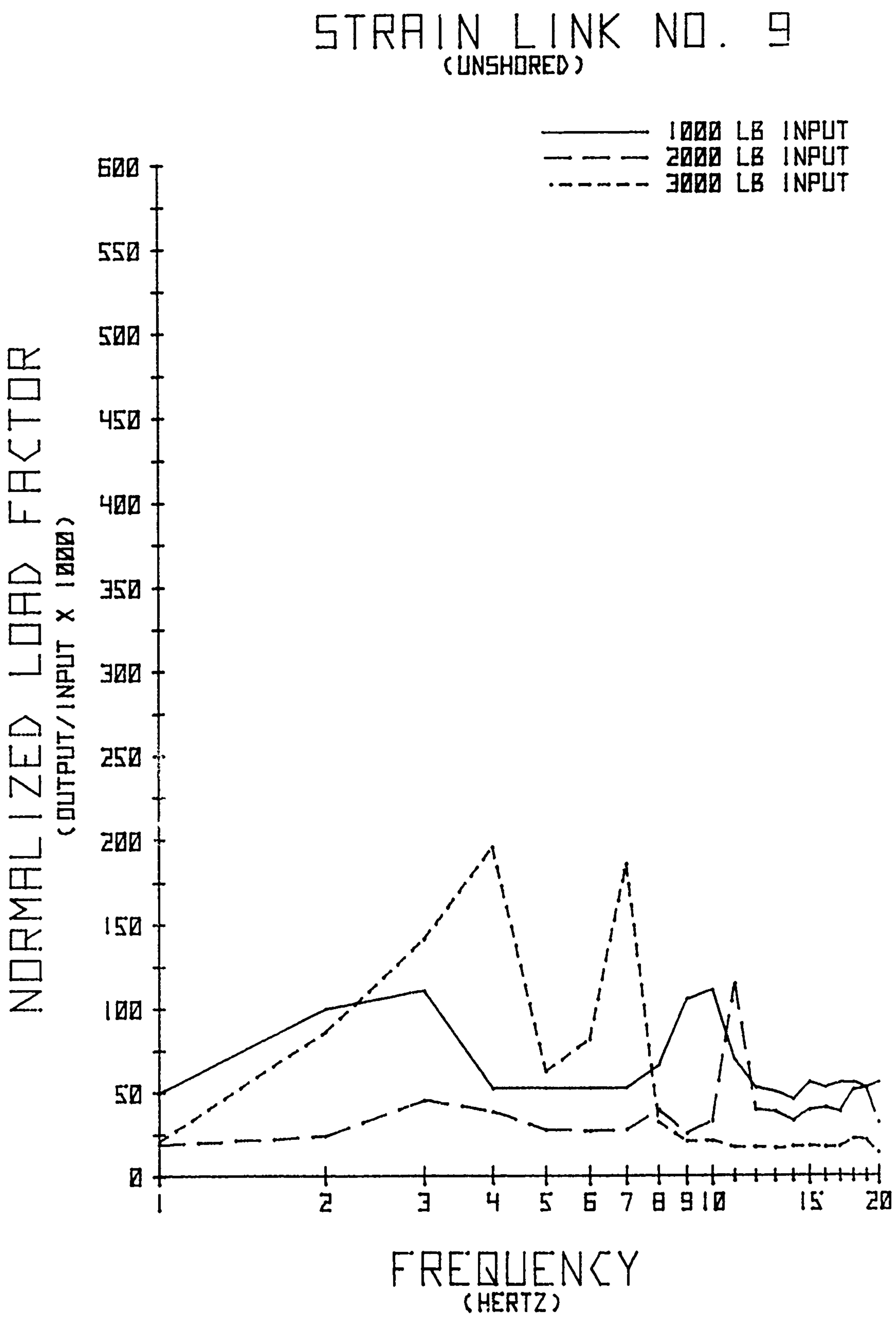

STRAIN LINK NO. 4
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

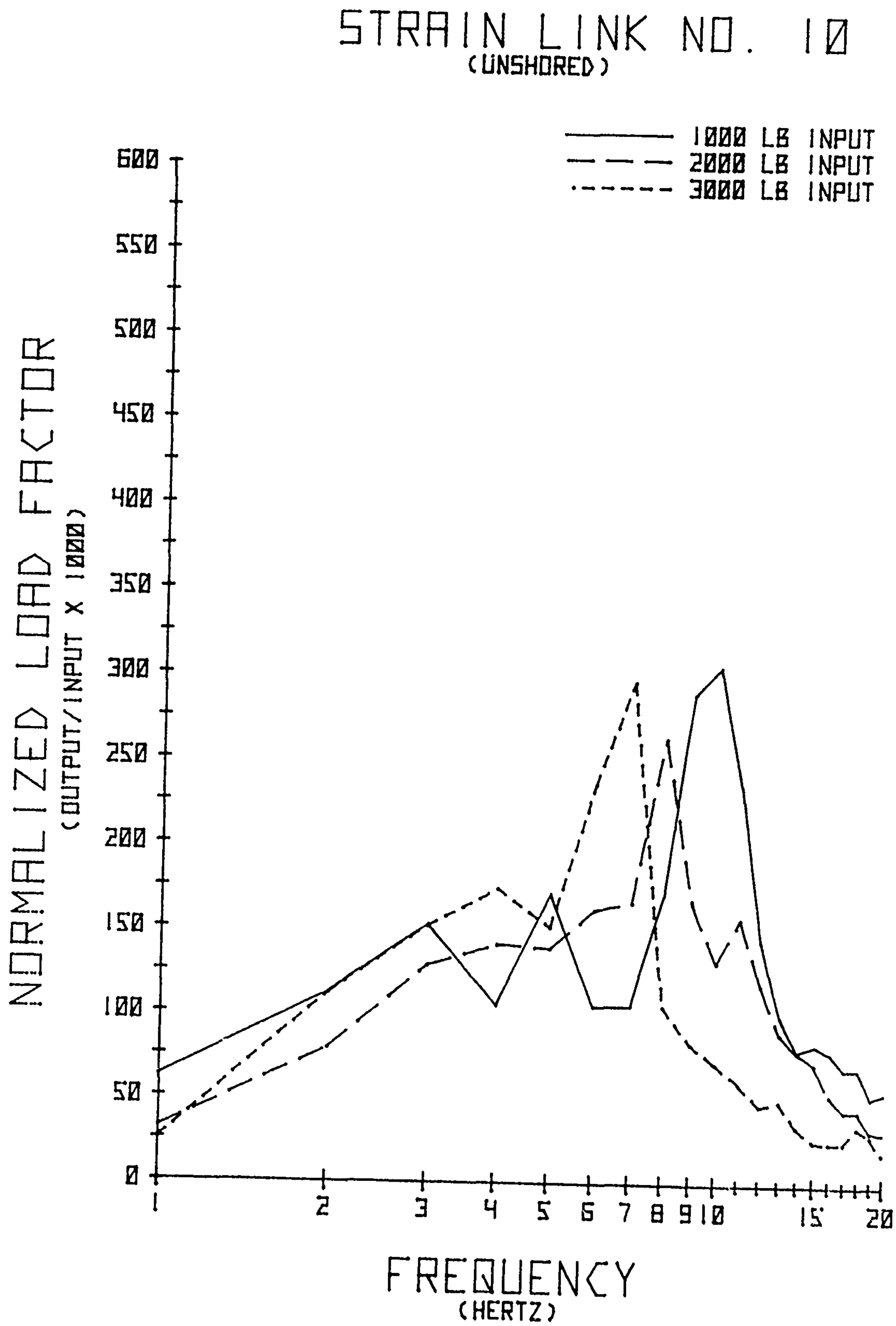

STRAIN LINK NO. 5
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

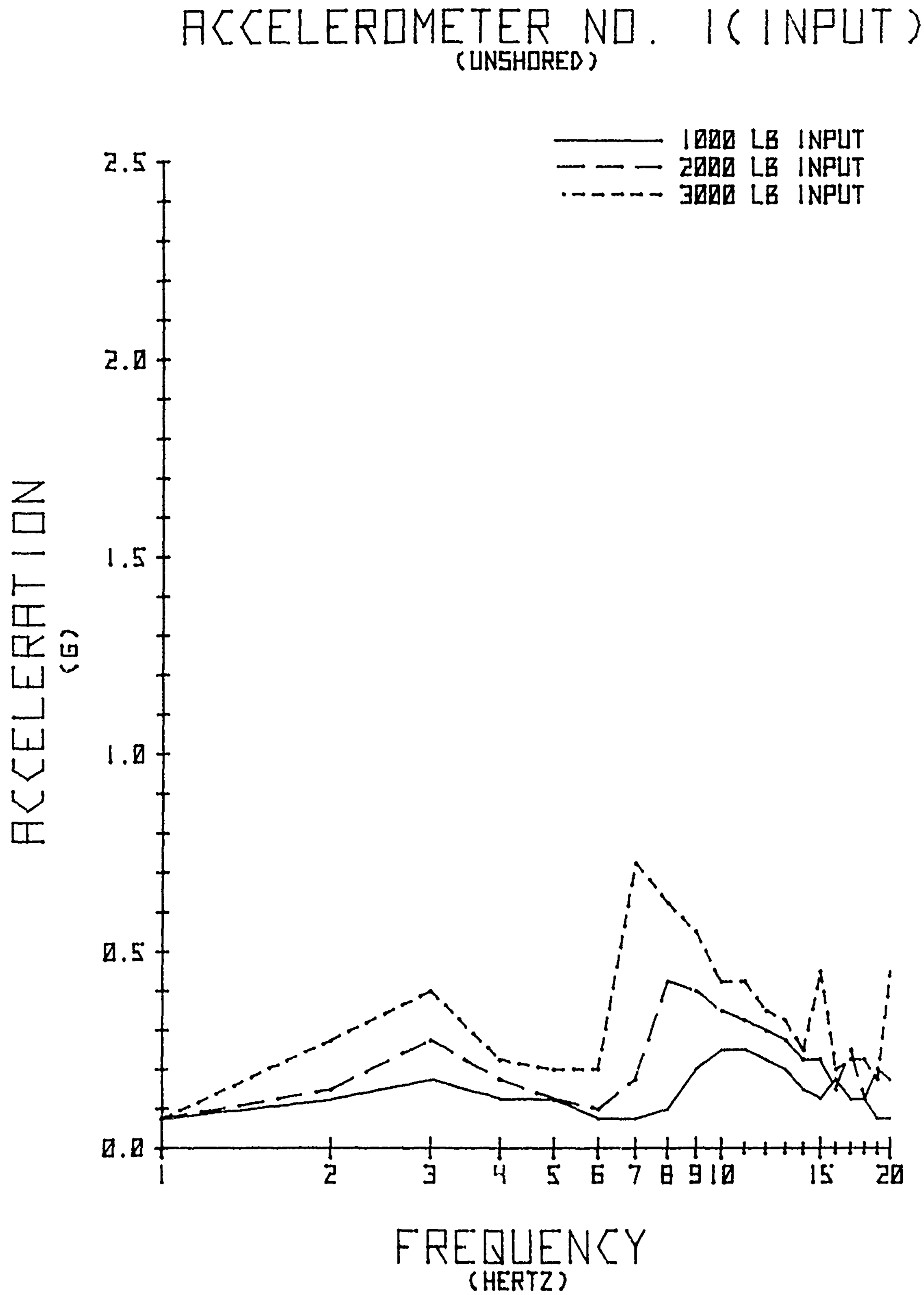

STRAIN LINK NO. 6
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

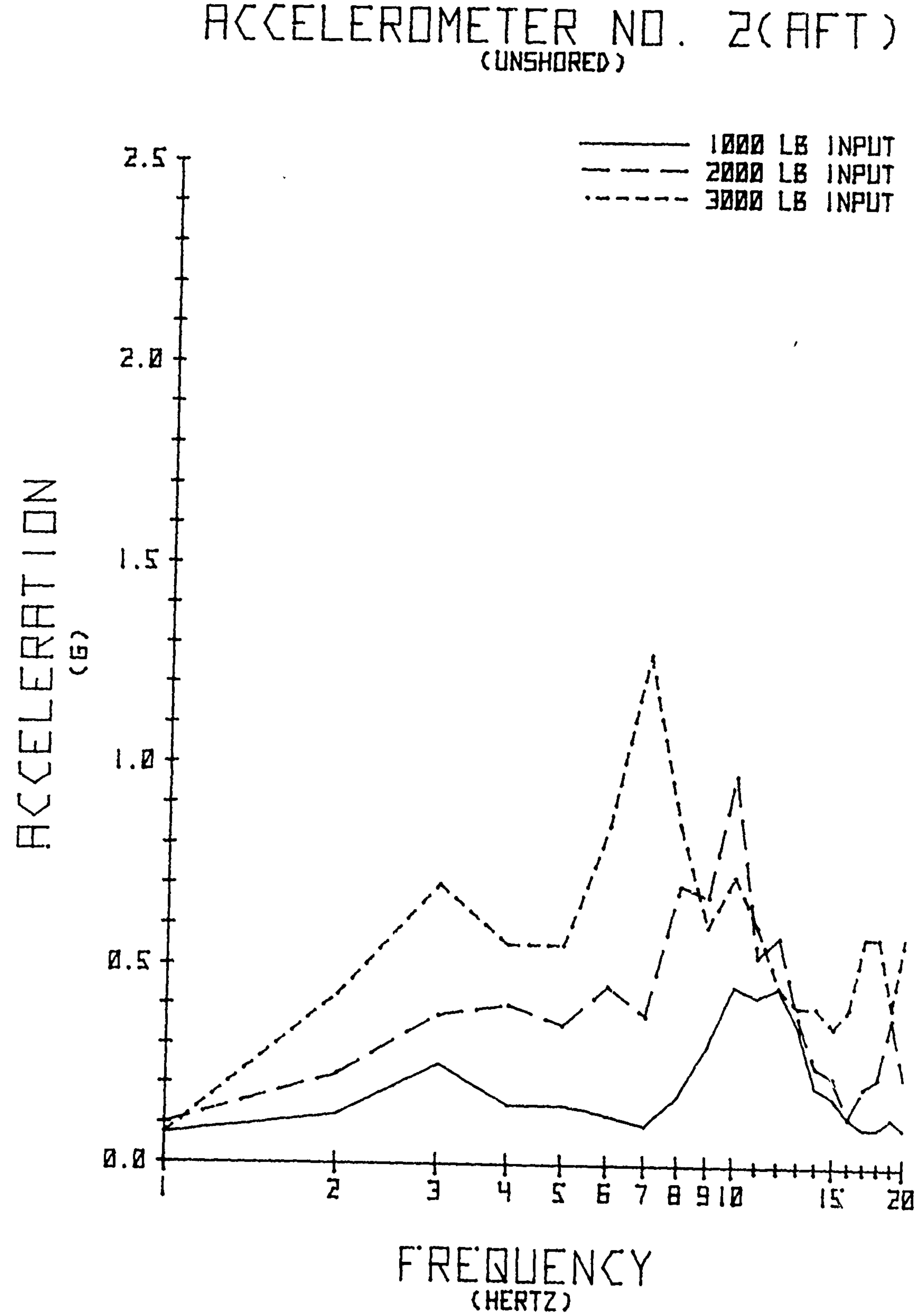

STRAIN LINK NO. 7
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

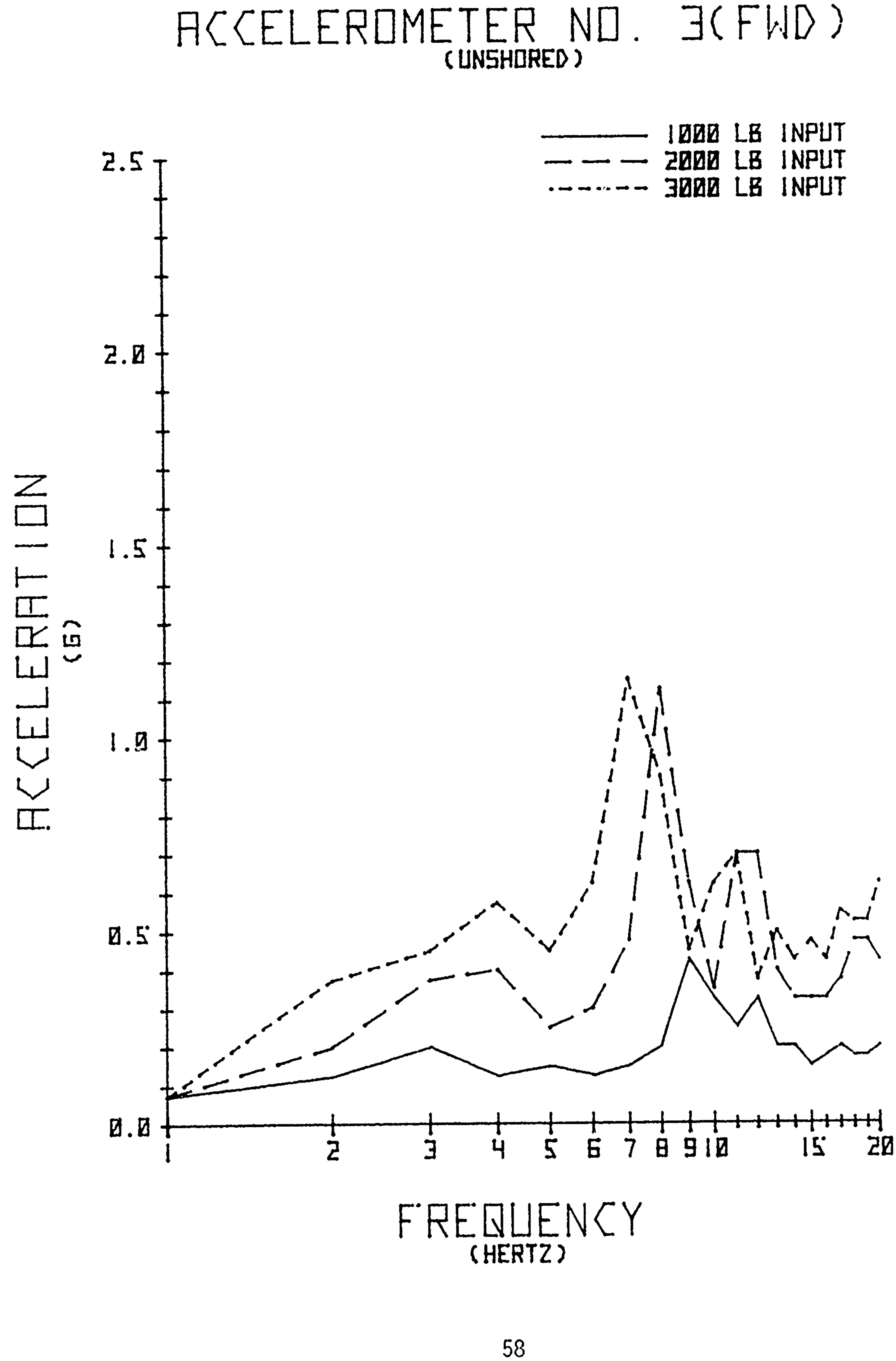

STRAIN LINK NO. 8
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 9
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

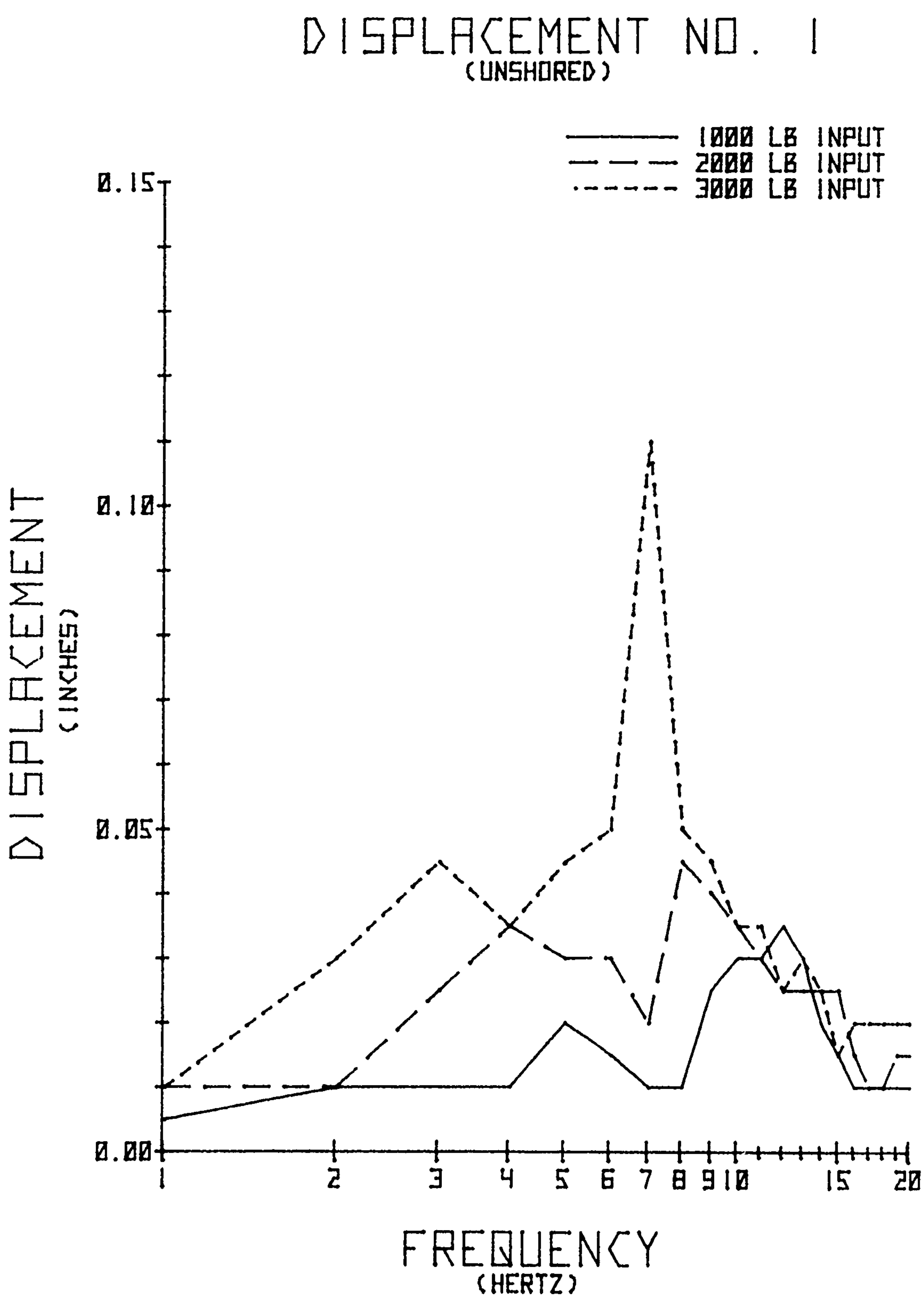

STRAIN LINK NO. 10
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

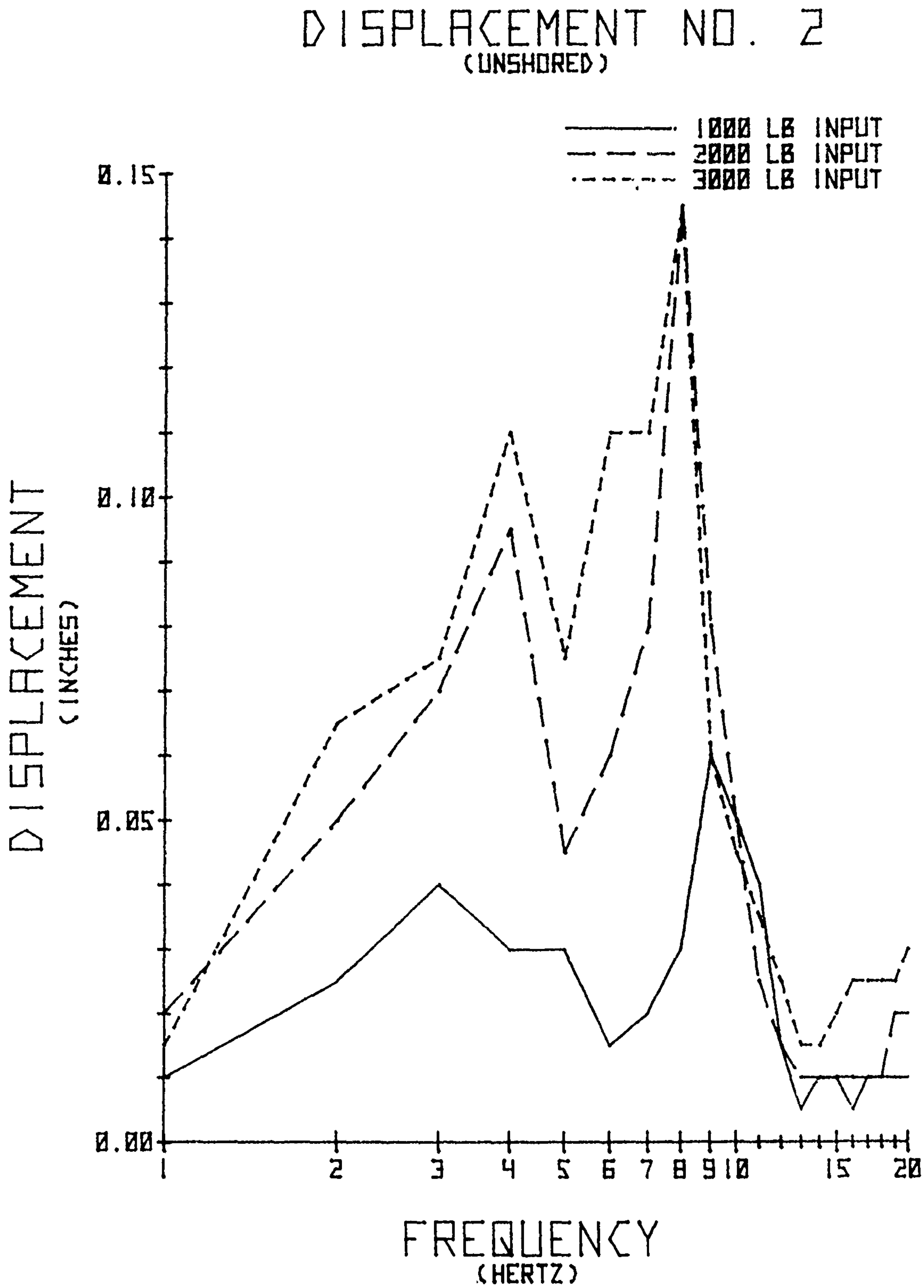

ACCELEROMETER NO. 1 (INPUT)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


ACCELEROMETER NO. 2(AFT)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

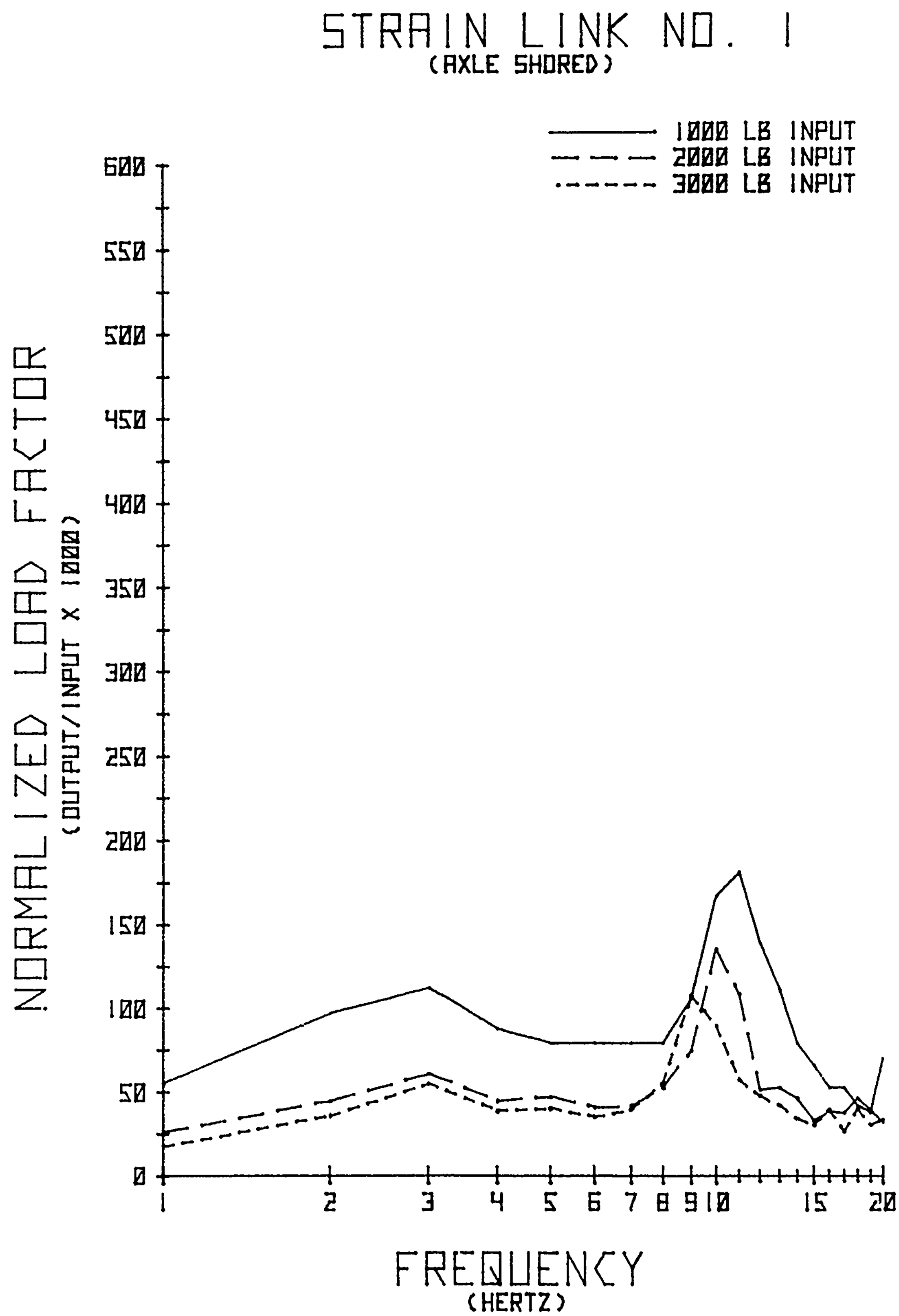


ACCELEROMETER NO. 3(FWD)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

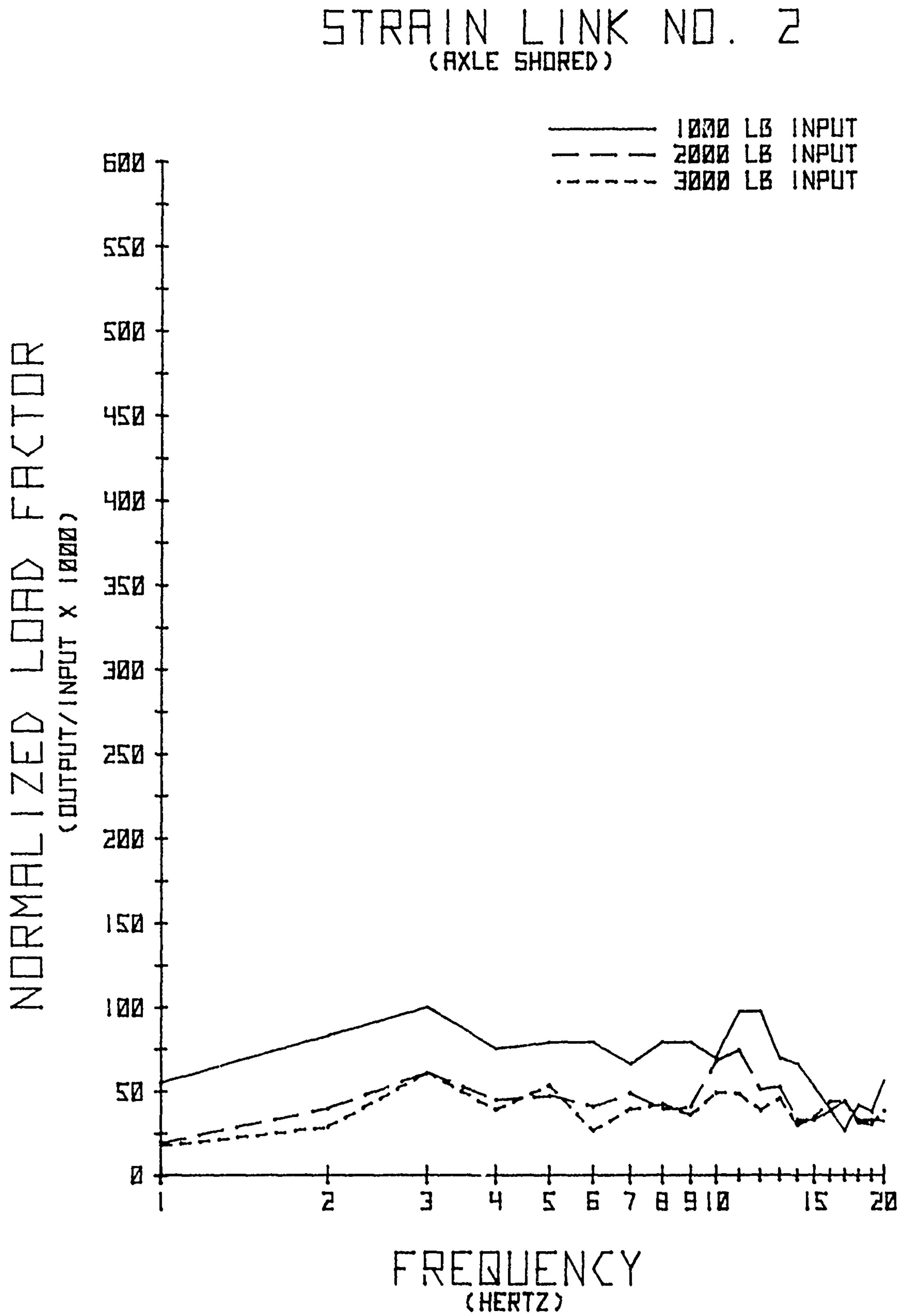

DISPLACEMENT NO. 1
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



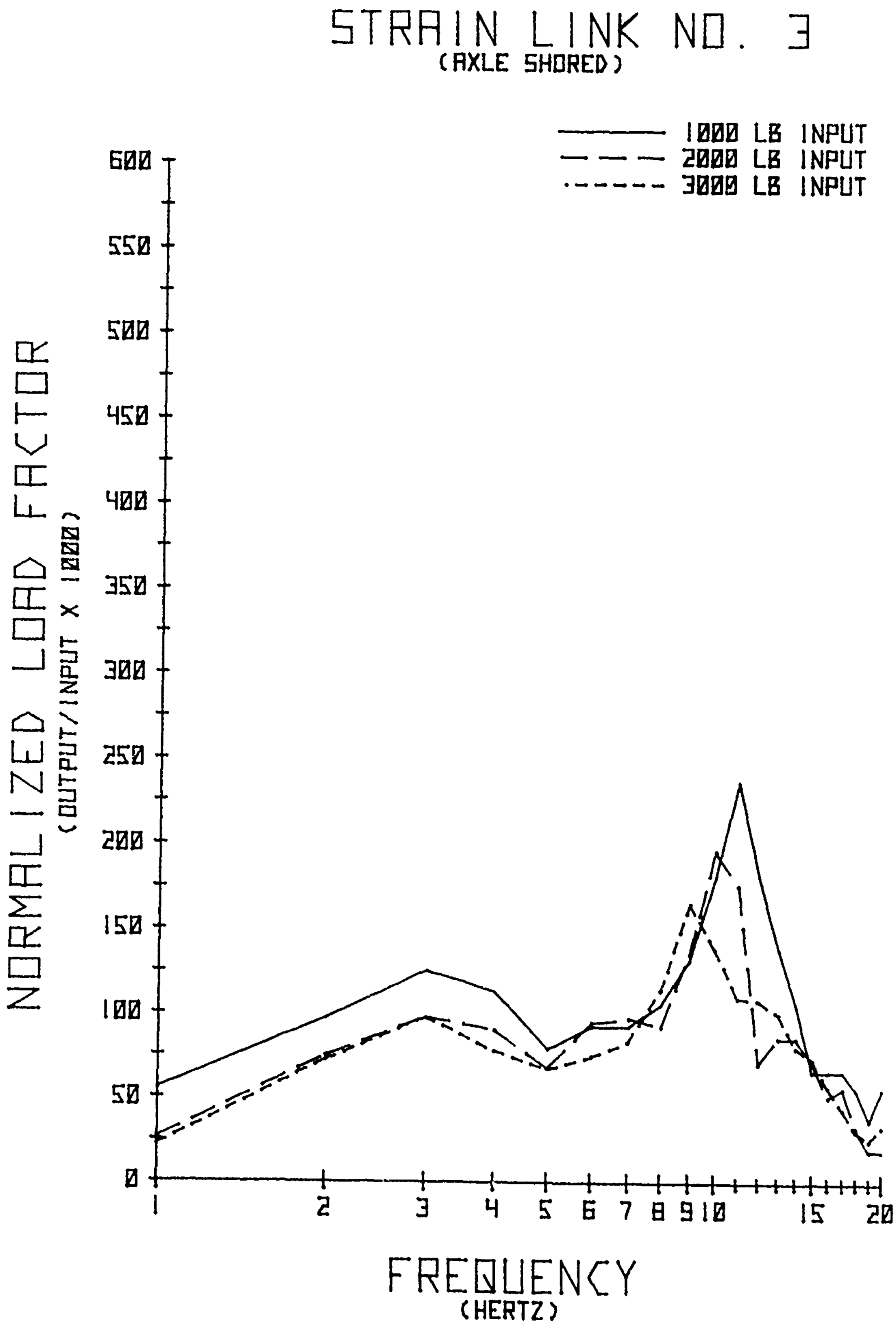
DISPLACEMENT NO. 2
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

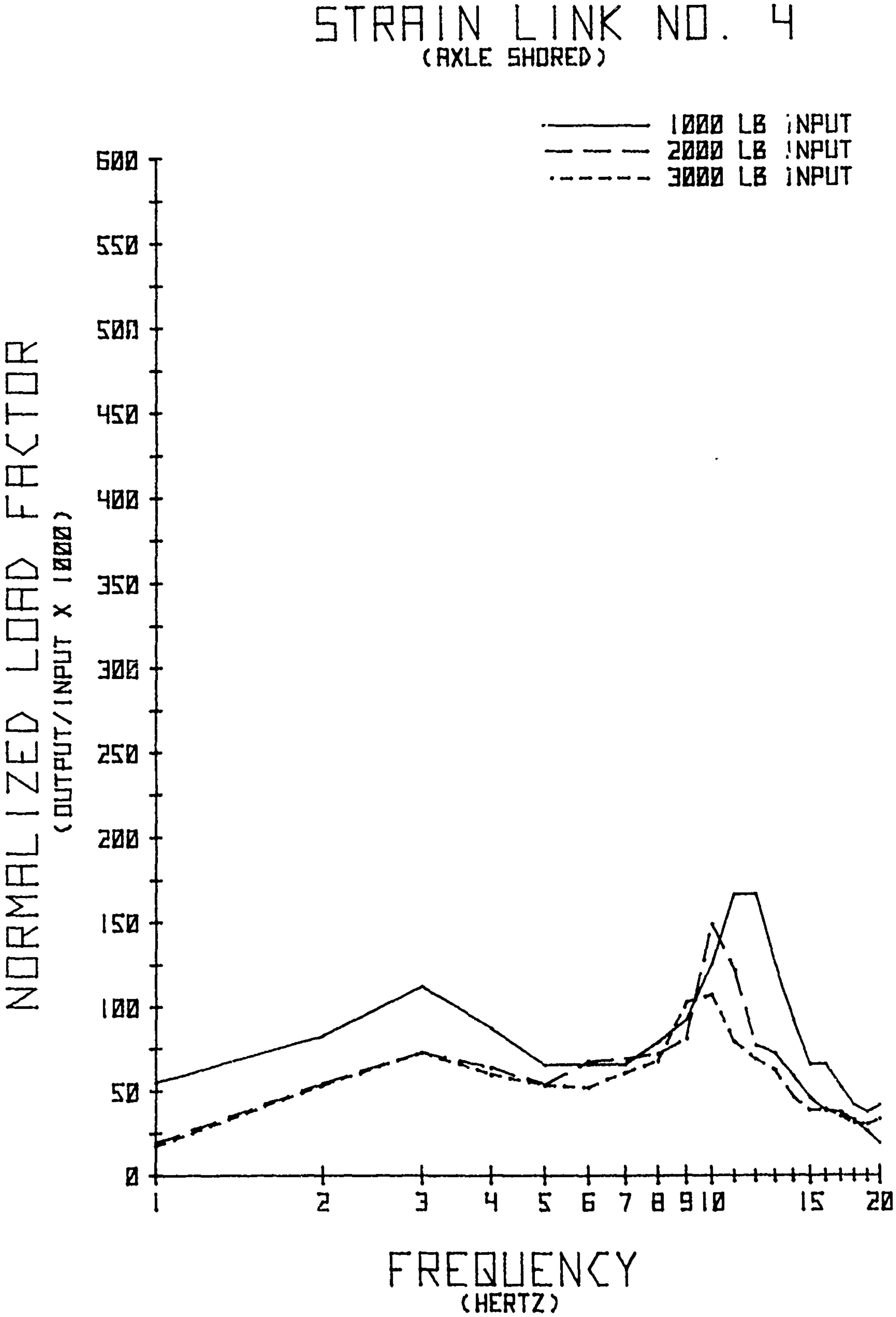


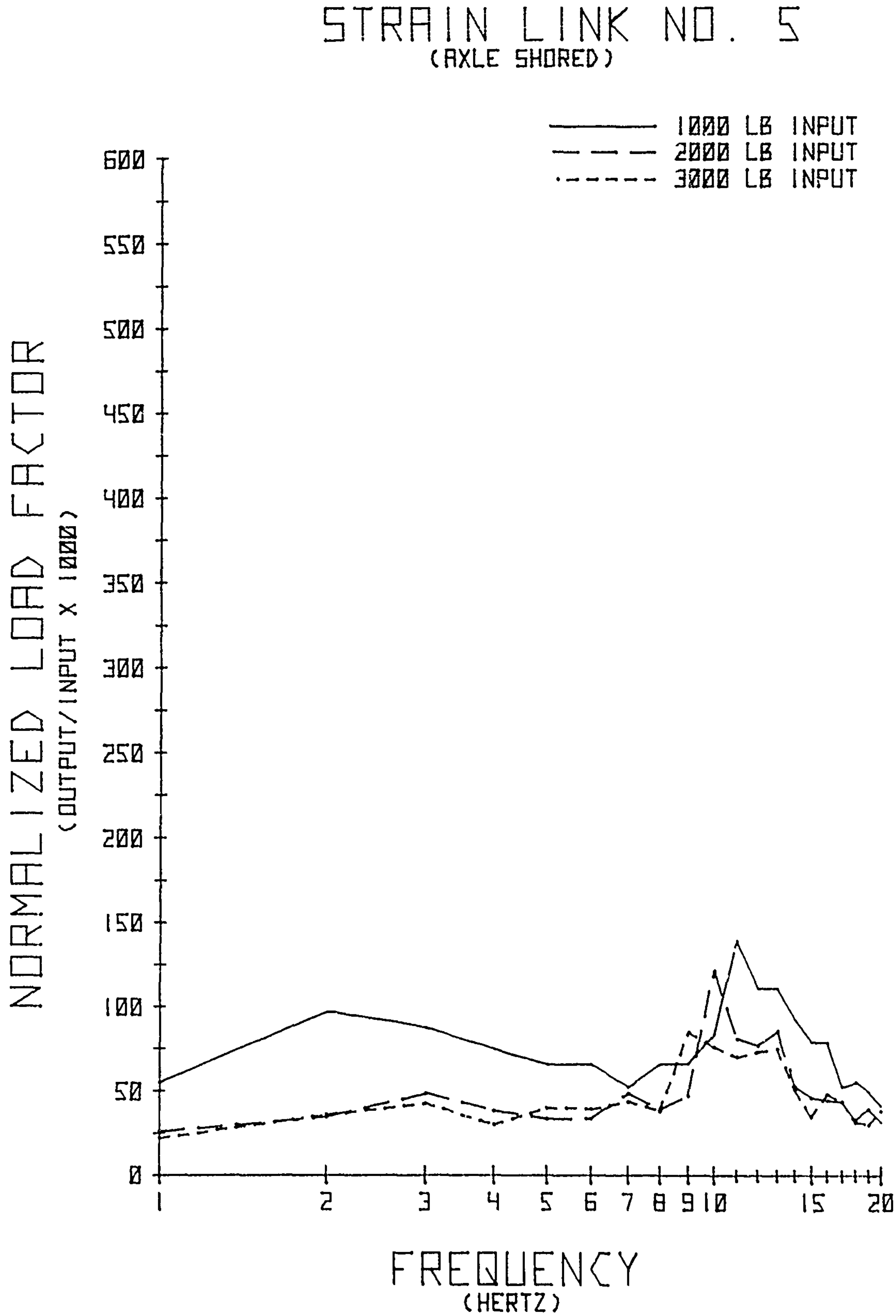
STRAIN LINK NO. 1
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



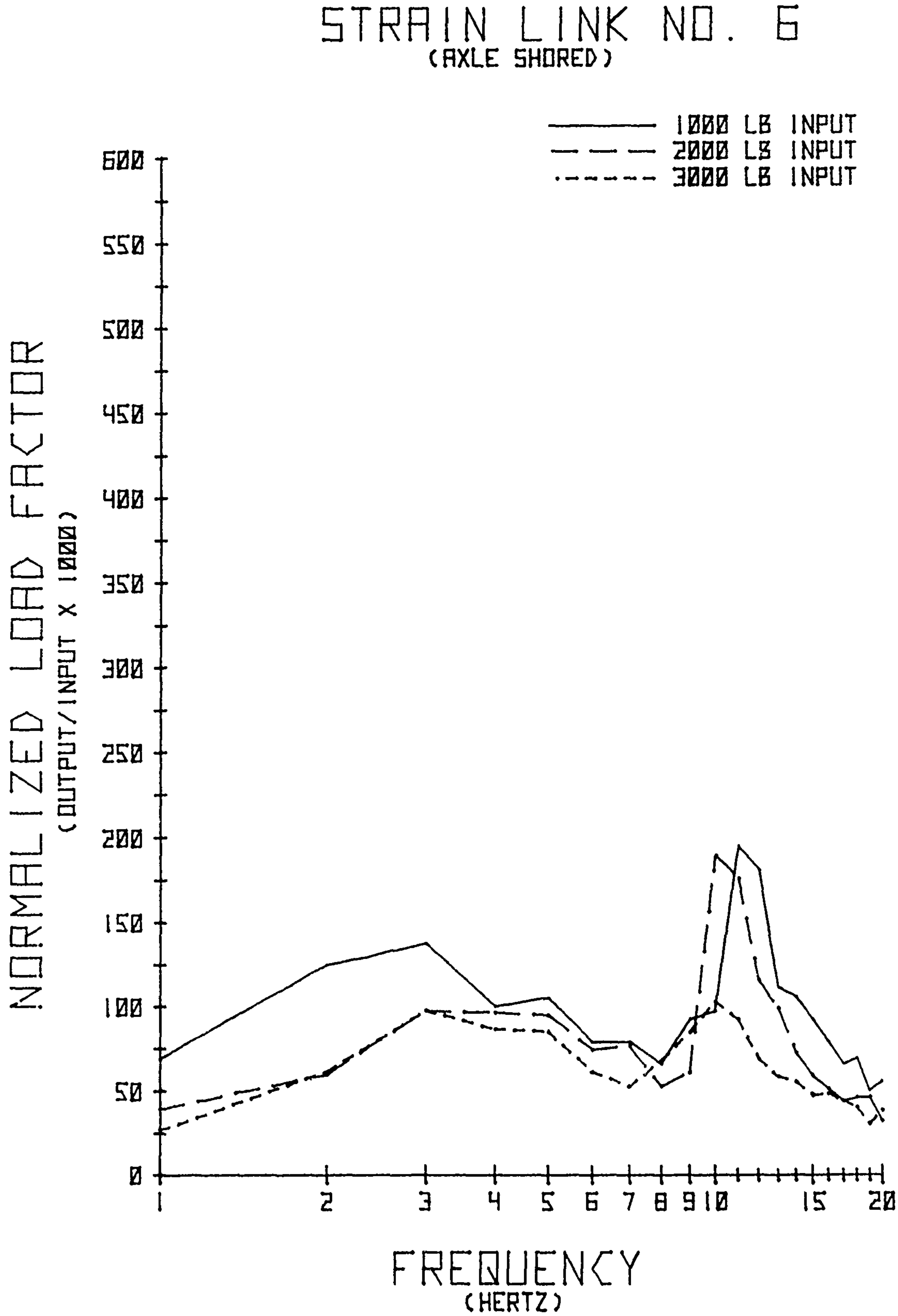
STRAIN LINK NO. 2
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

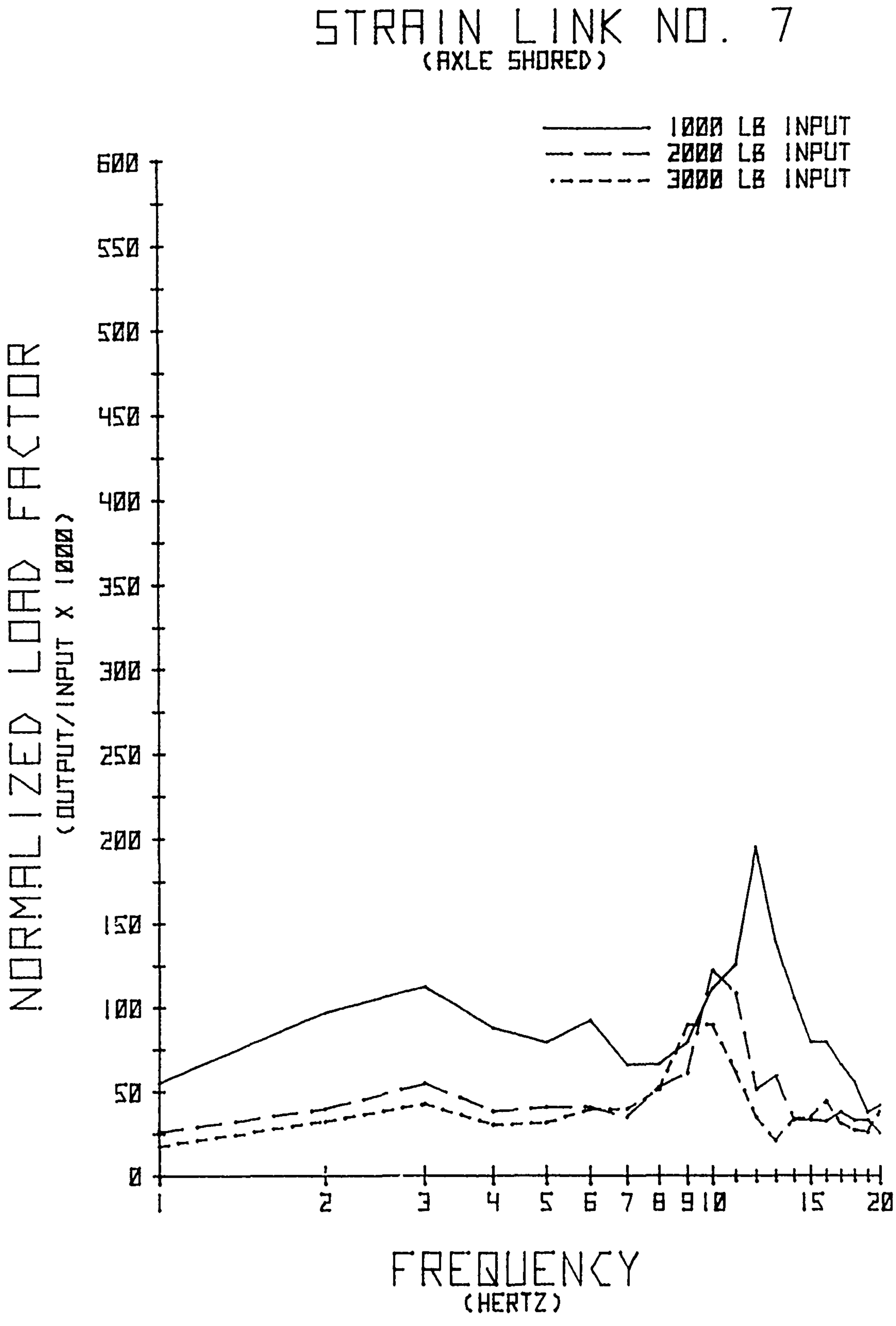

STRAIN LINK NO. 3
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

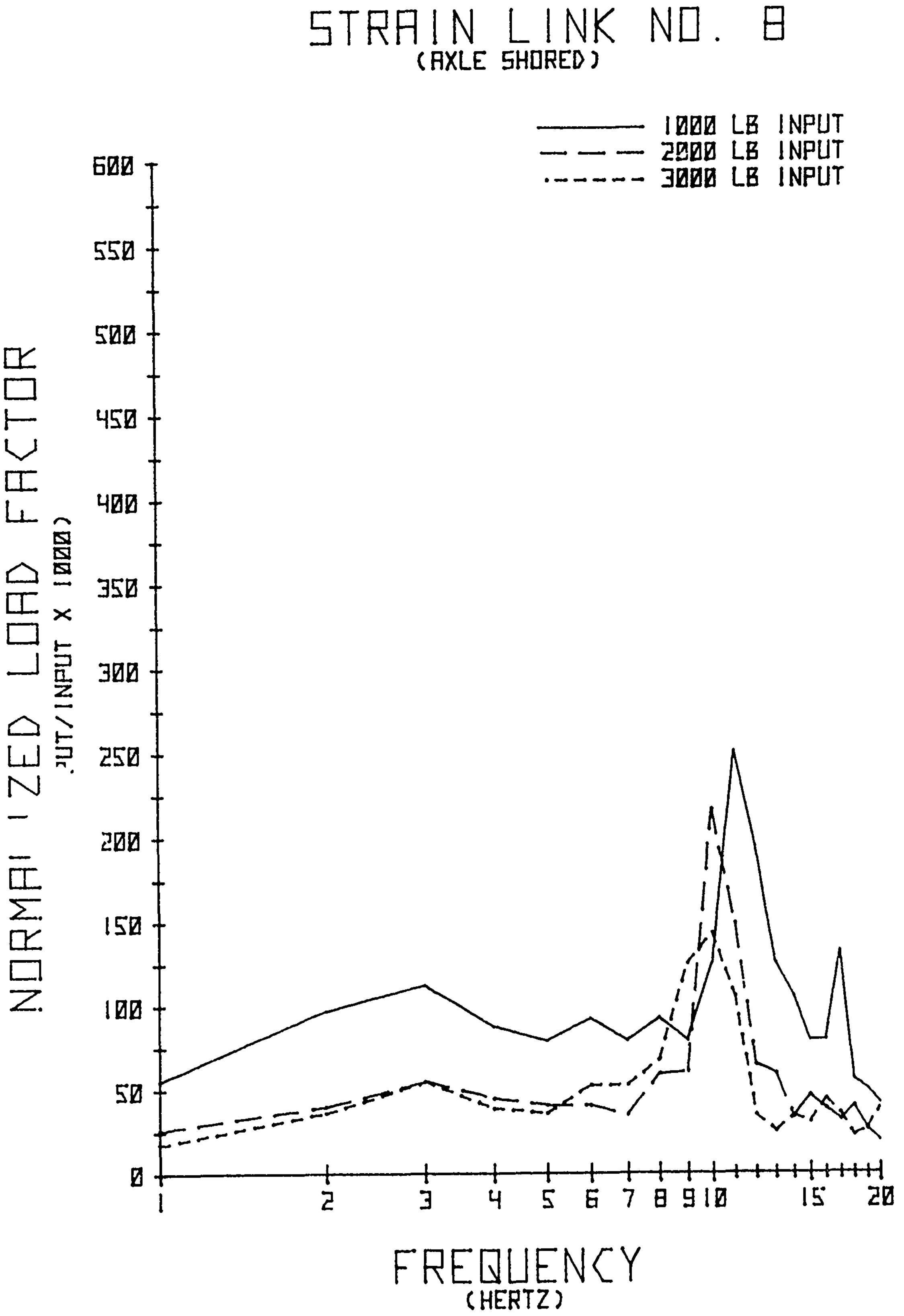

STRAIN LINK NO. 4
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

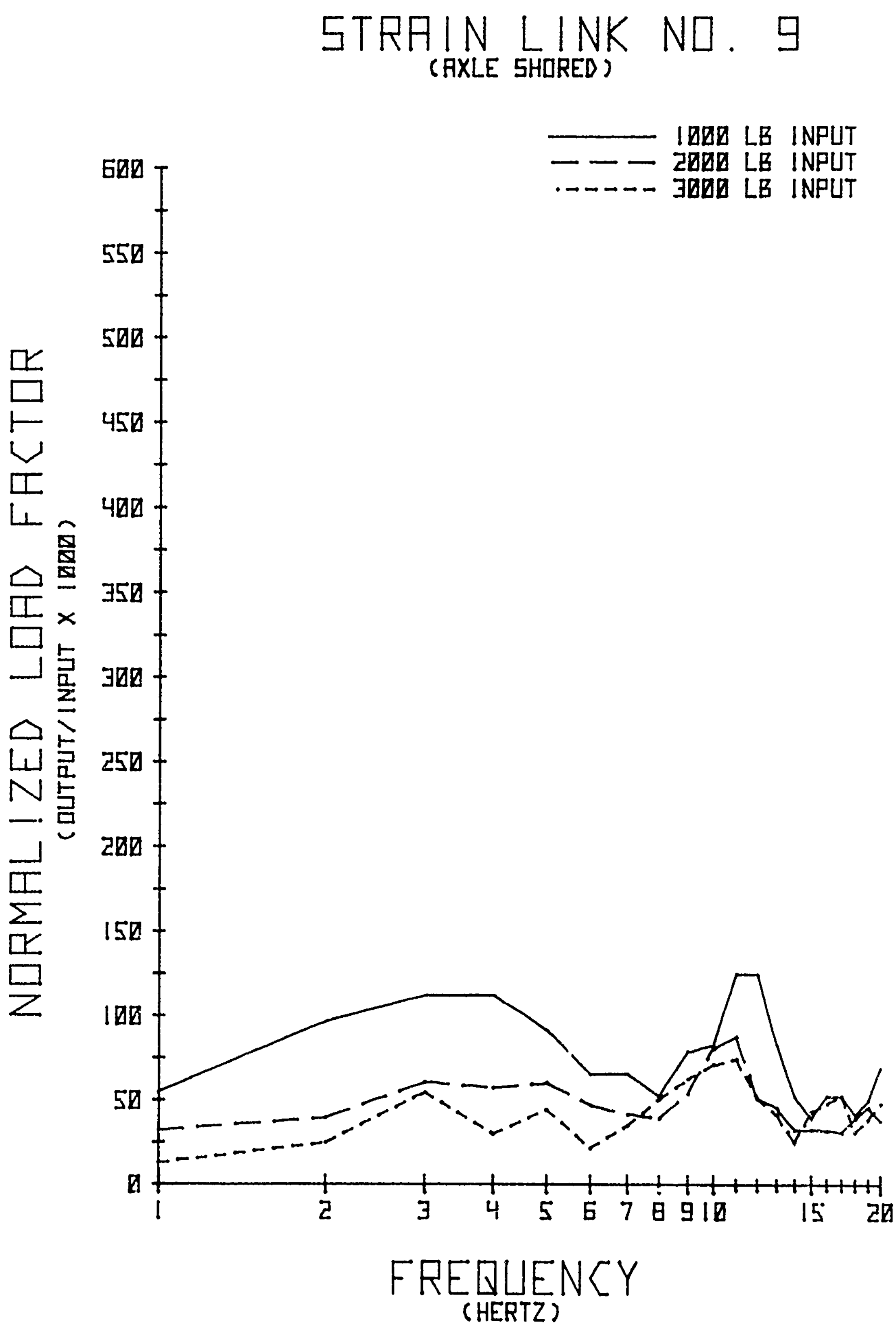


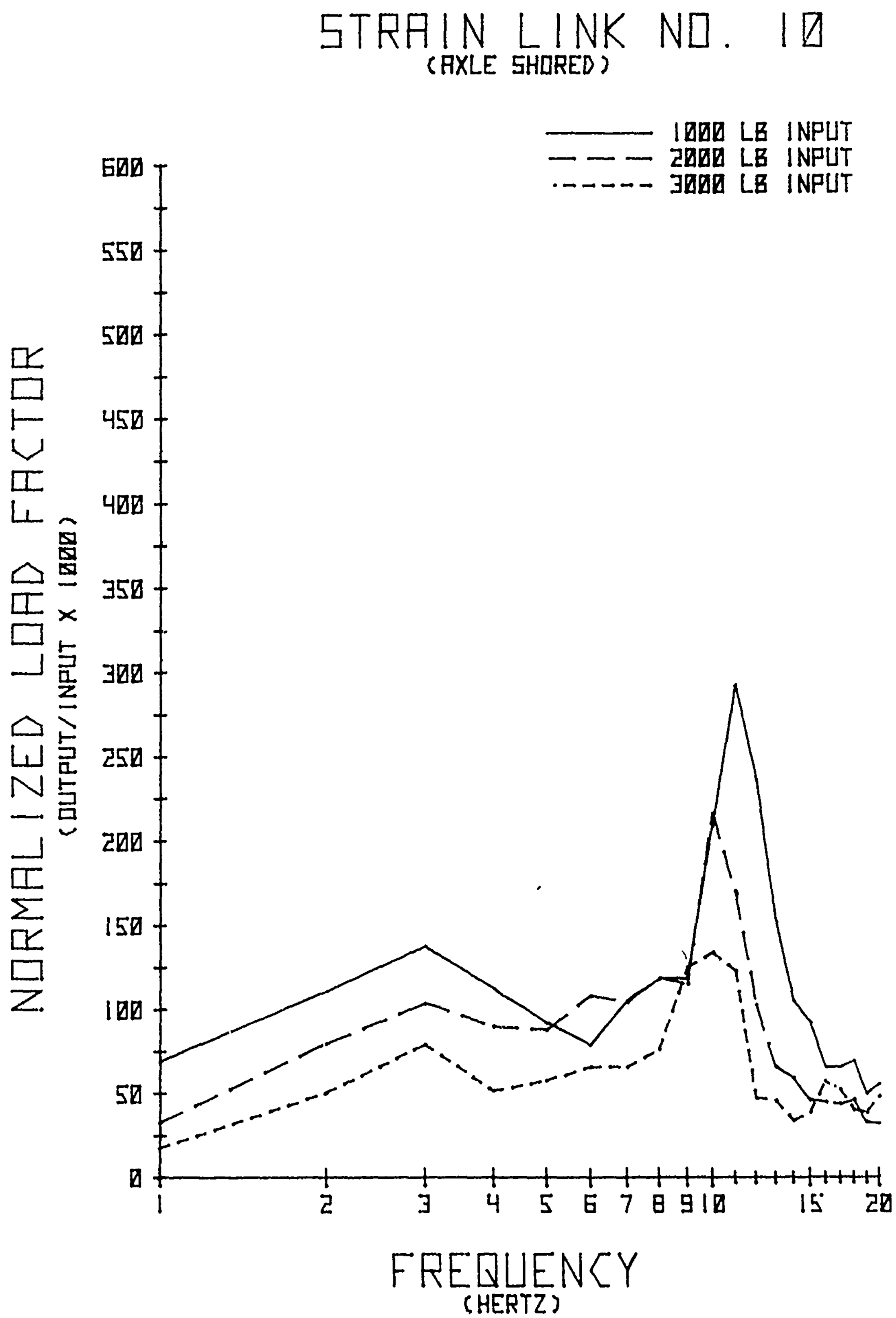
STRAIN LINK NO. 5
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

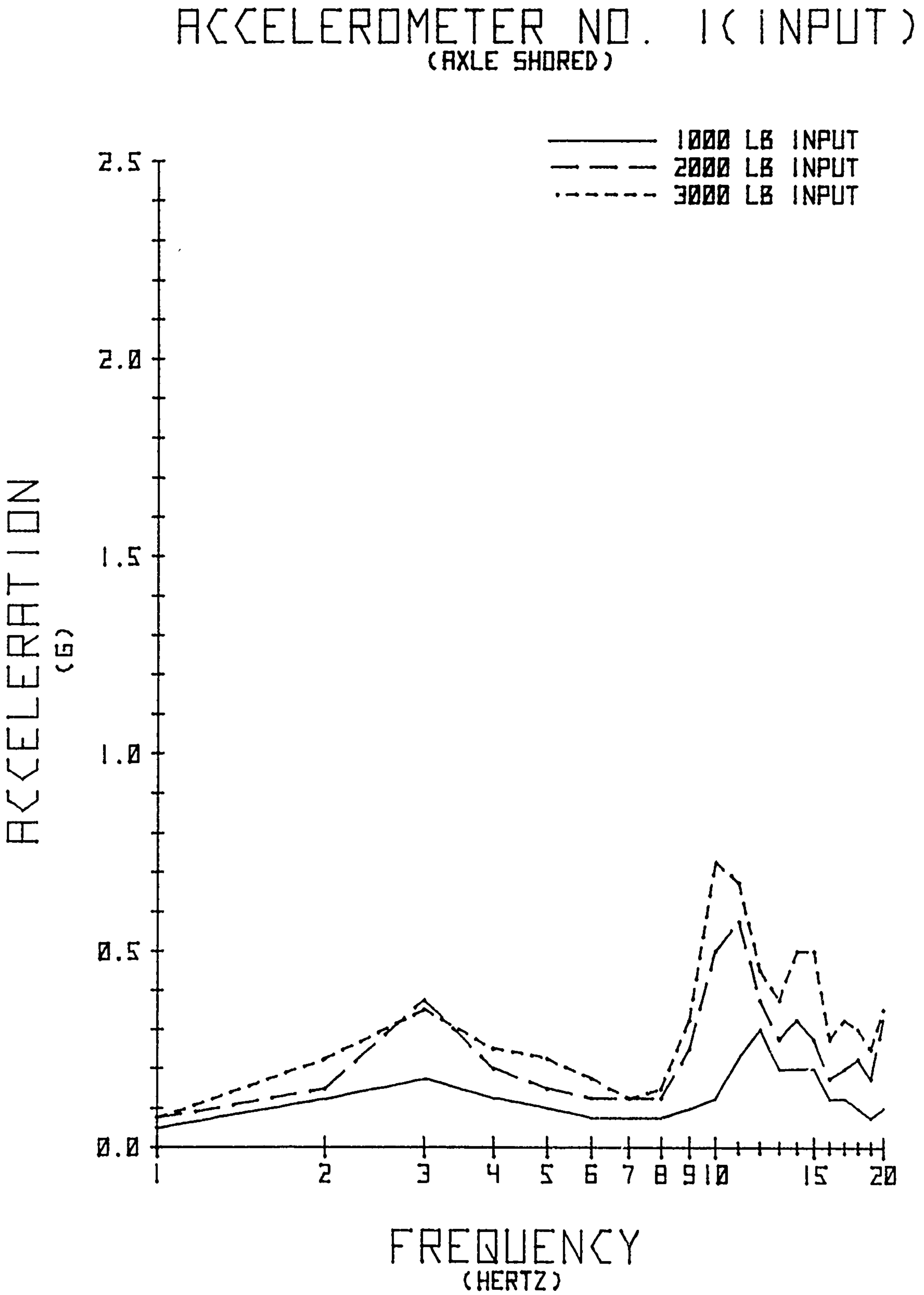

STRAIN LINK NO. 6
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

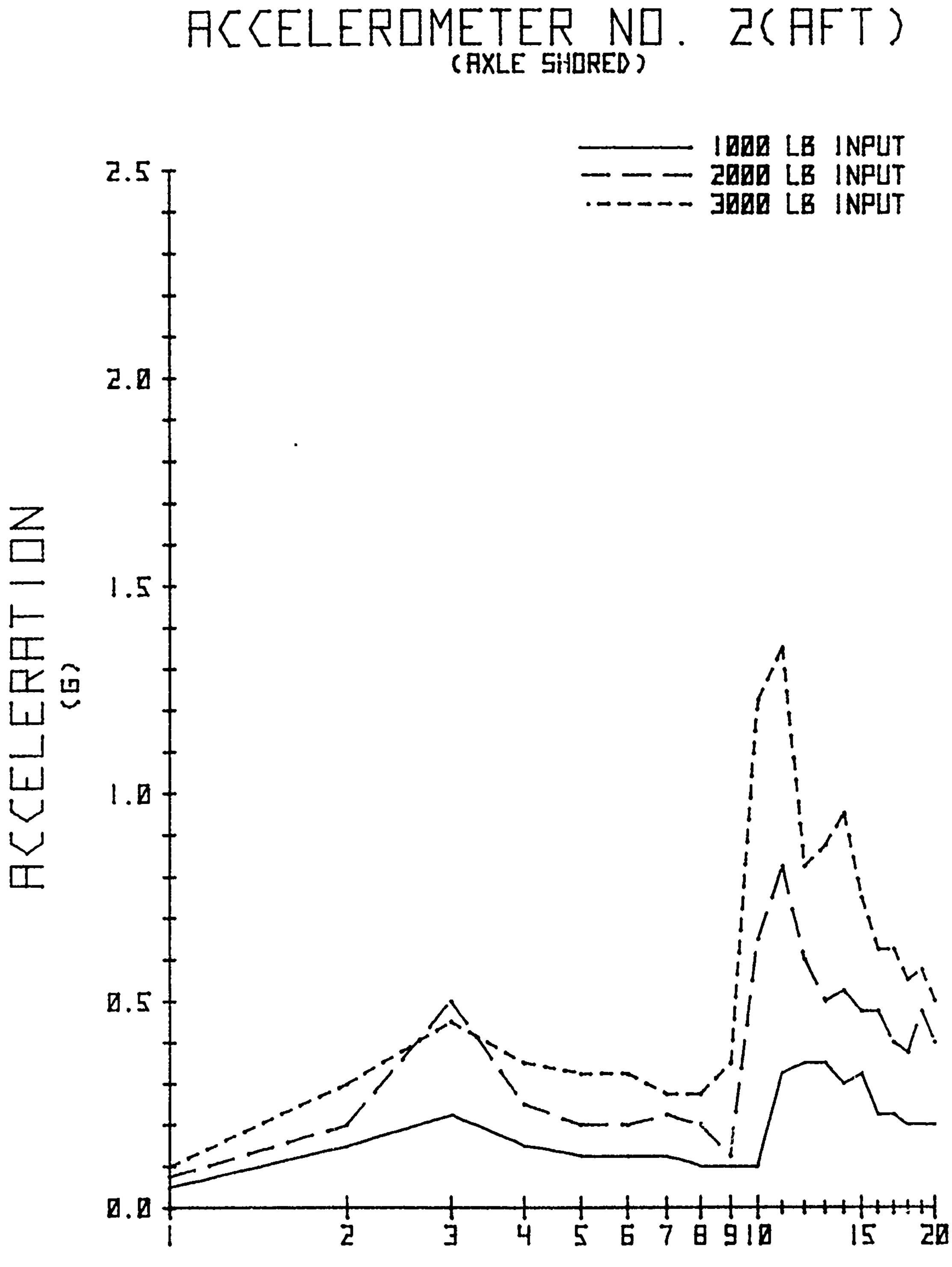

STRAIN LINK NO. 7
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 8
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

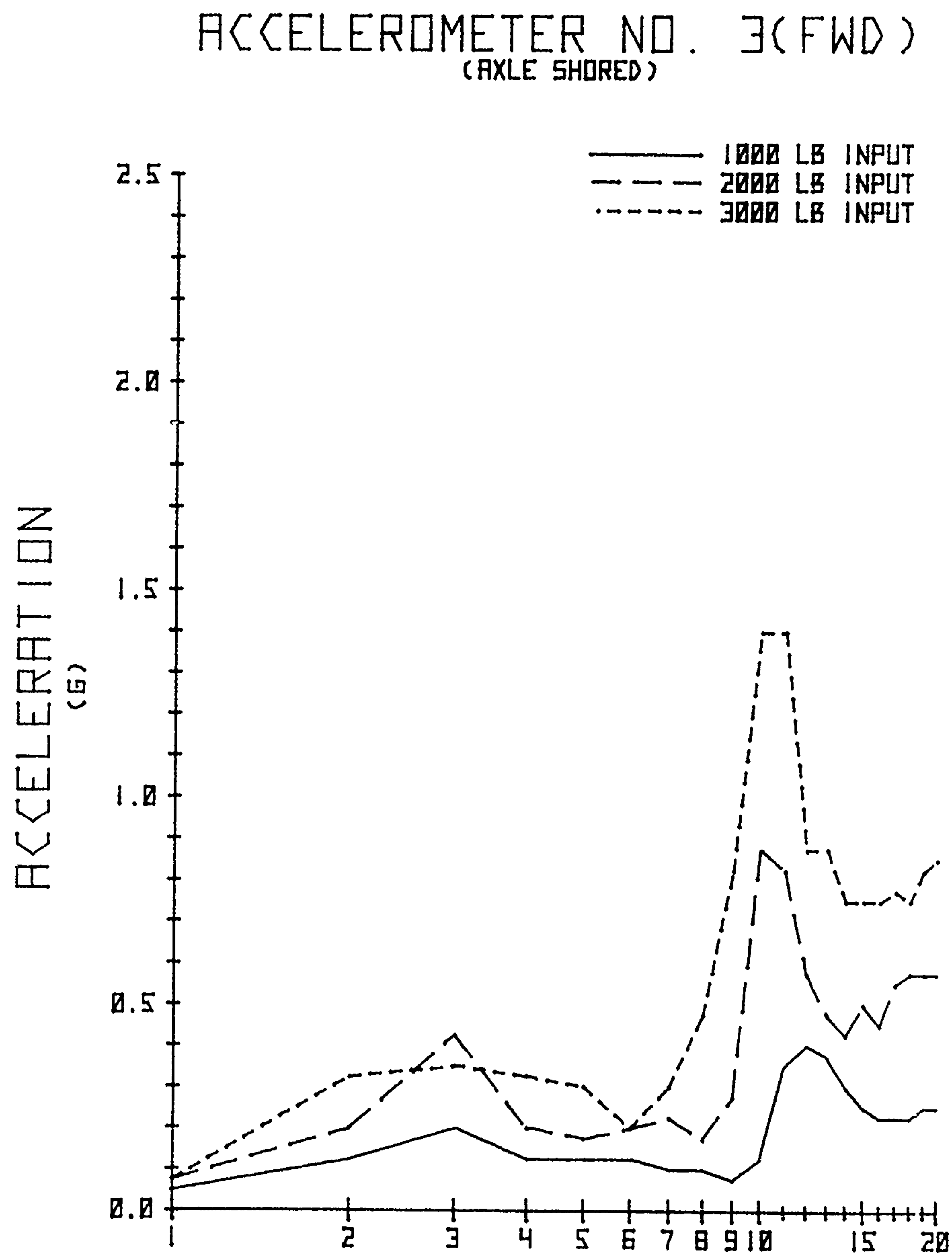

STRAIN LINK NO. 9
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

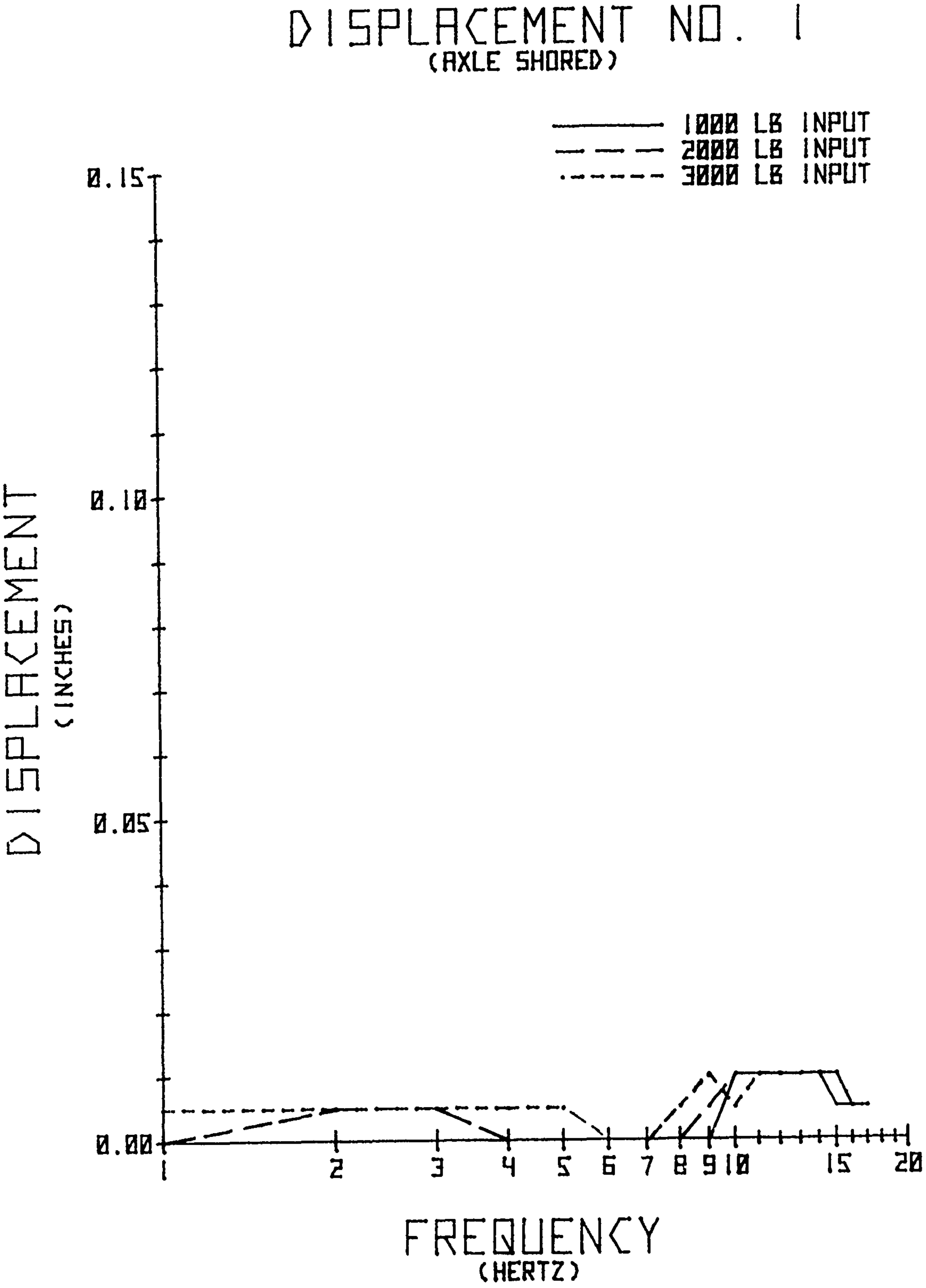

STRAIN LINK NO. 10
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


ACCELEROMETER NO. 1(INPUT)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

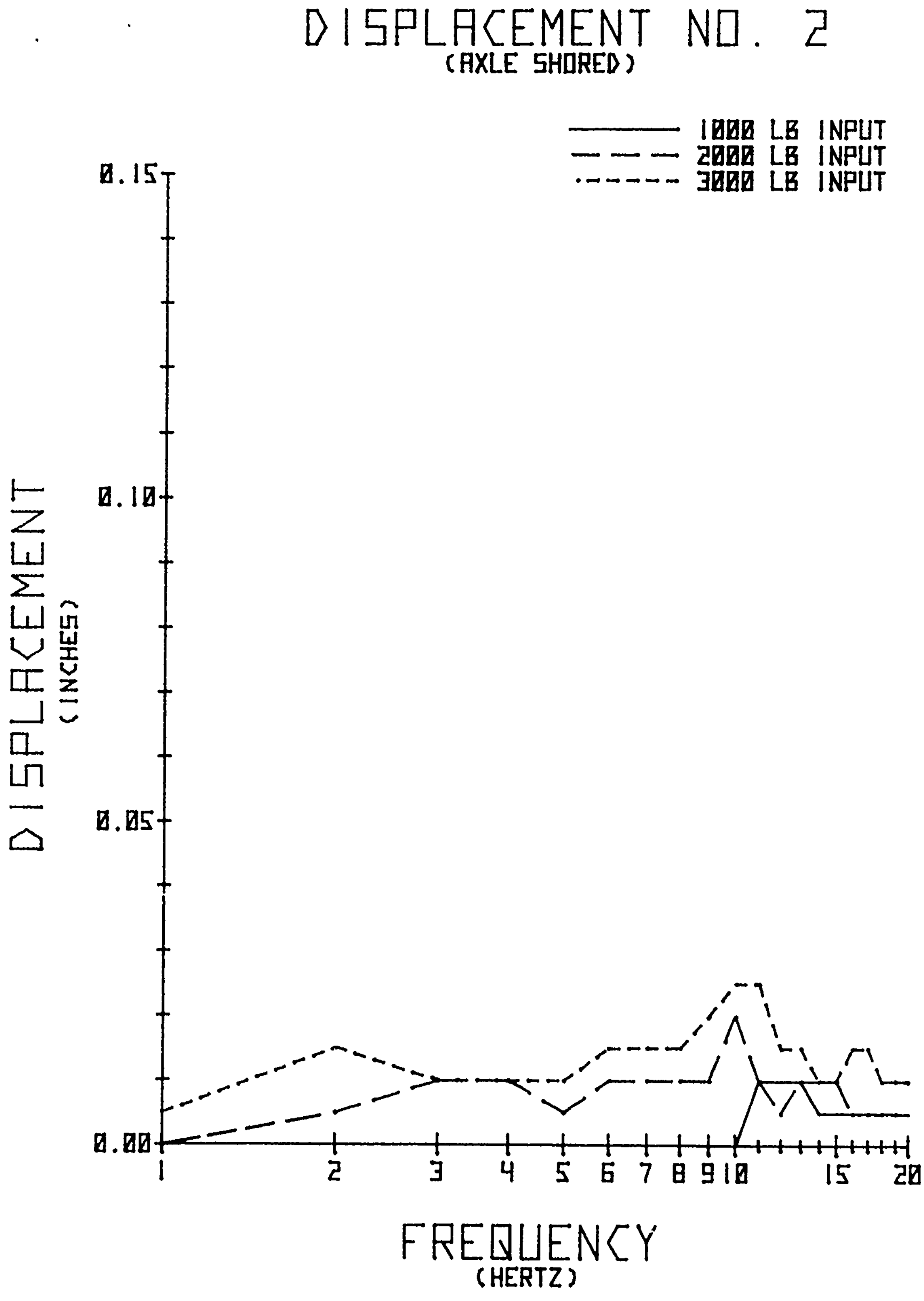


ACCELEROMETER NO. 2(AFT)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


ACCELEROMETER NO. 3(FWD)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

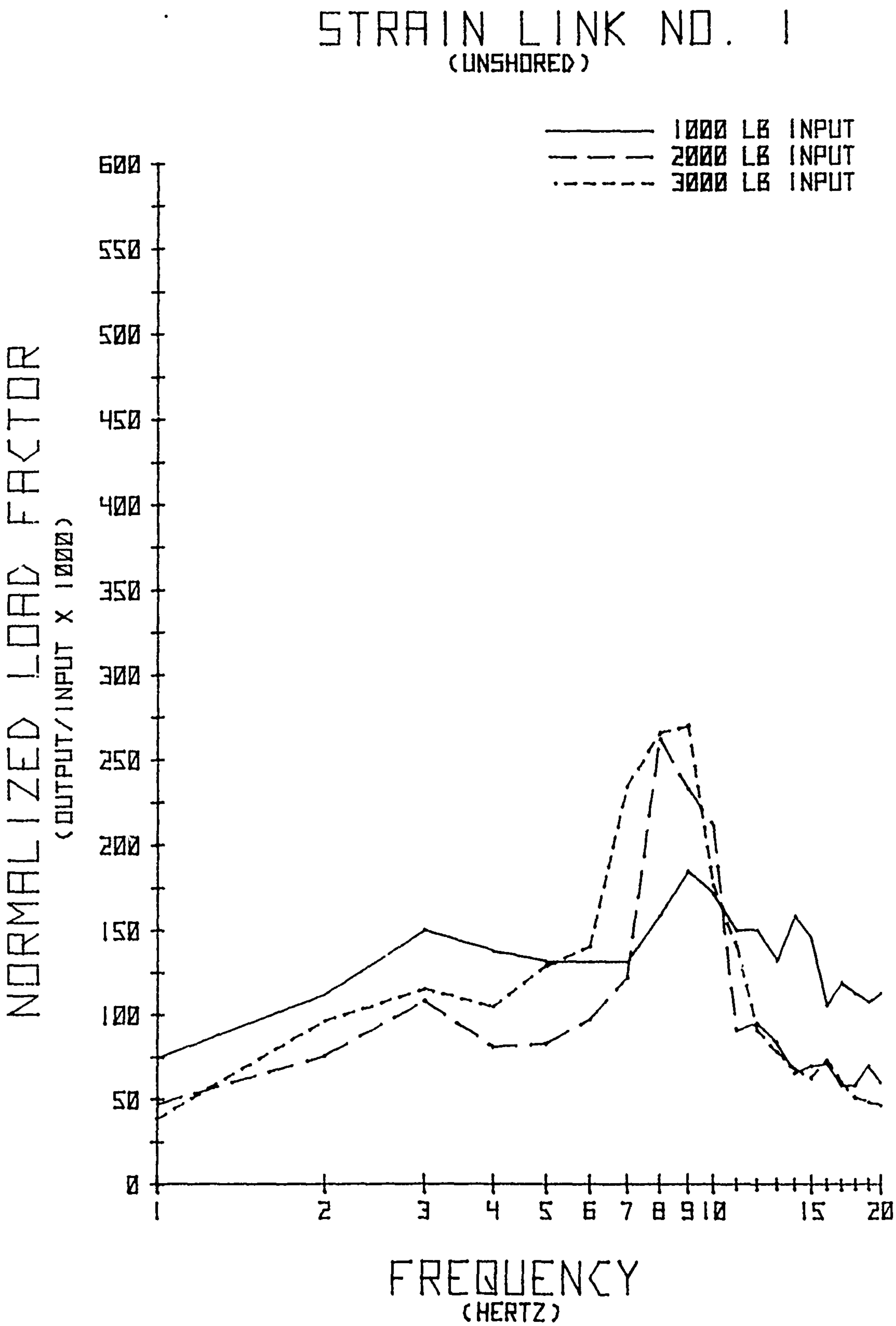


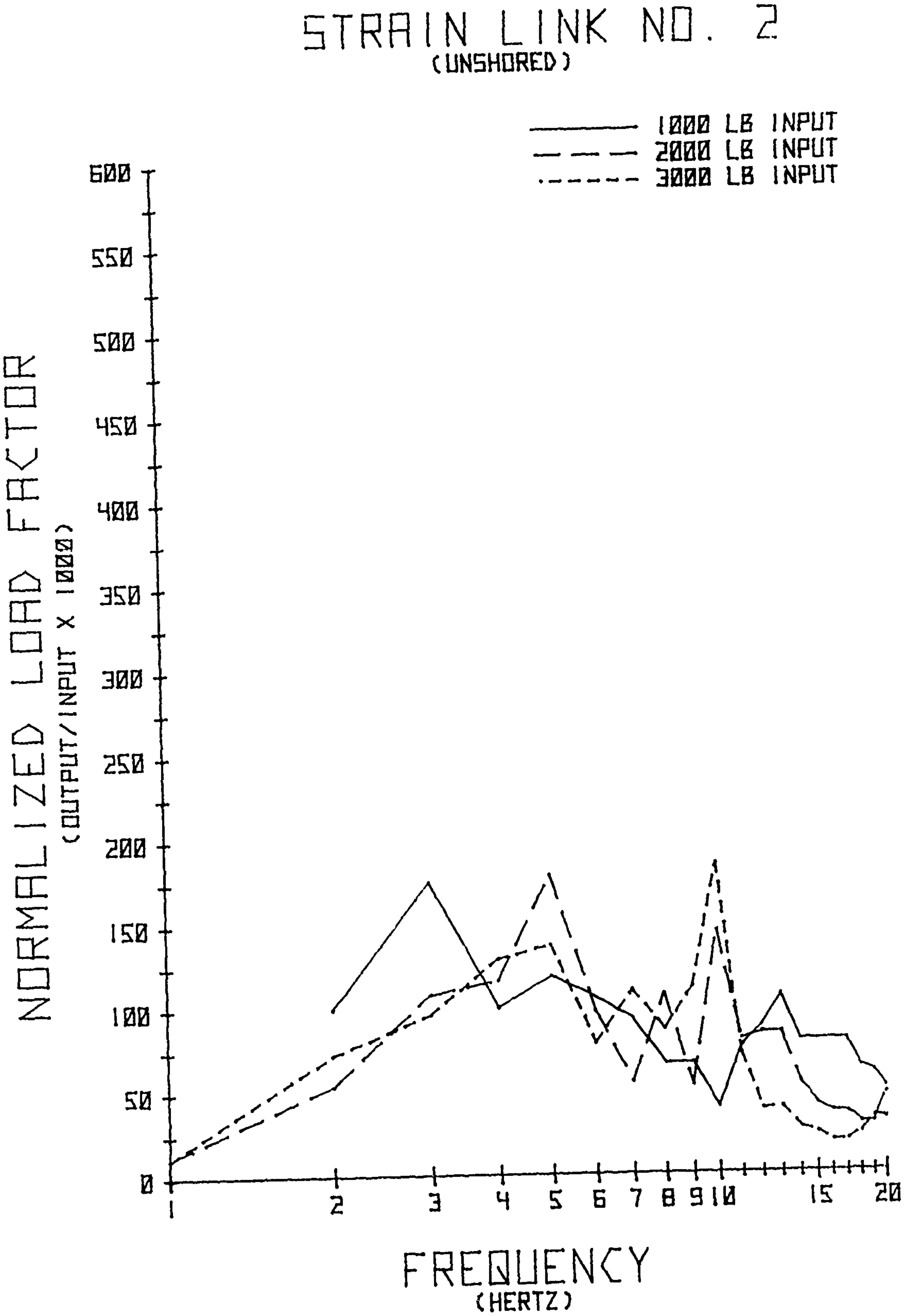
DISPLACEMENT NO. 1
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

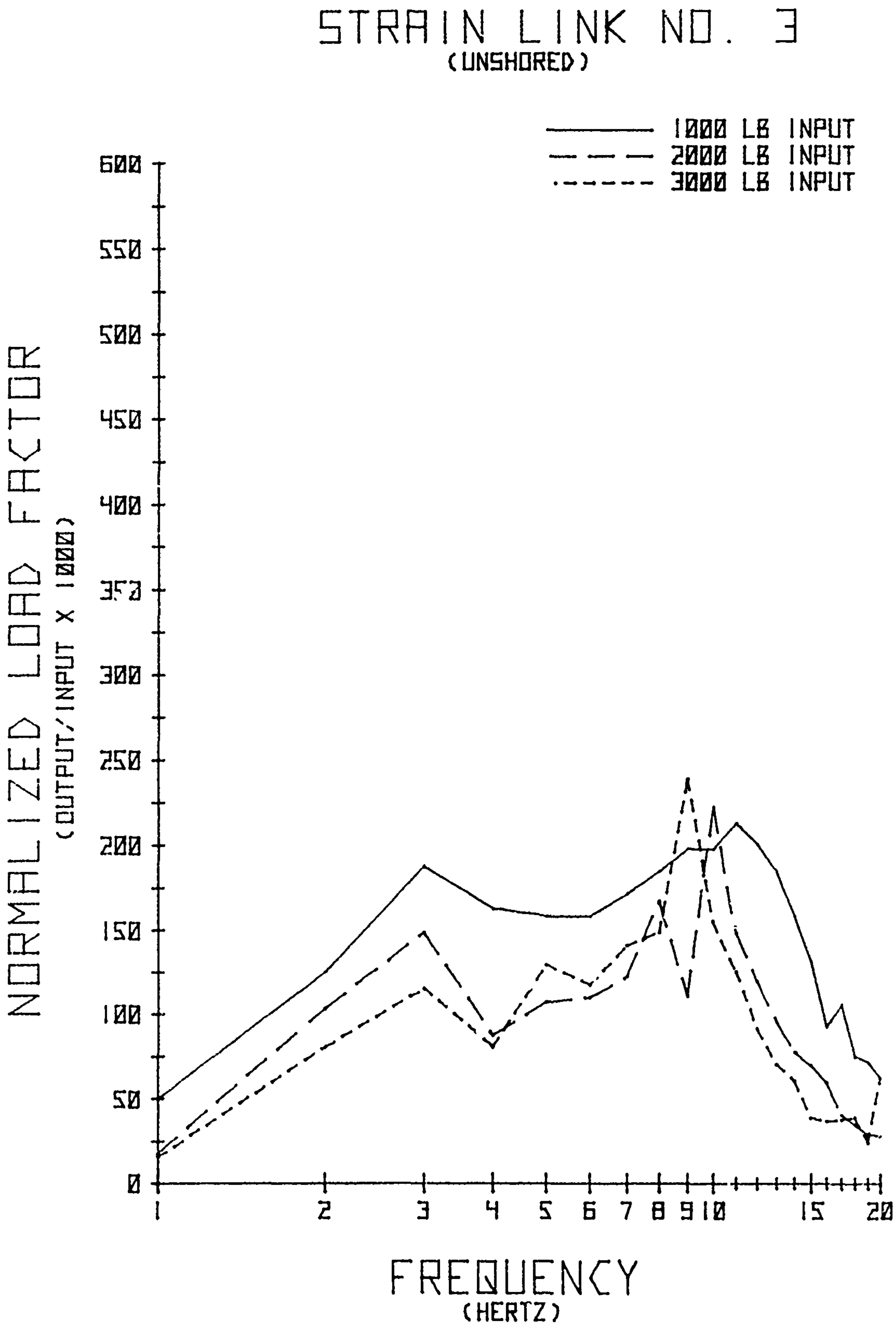

DISPLACEMENT NO. 2
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

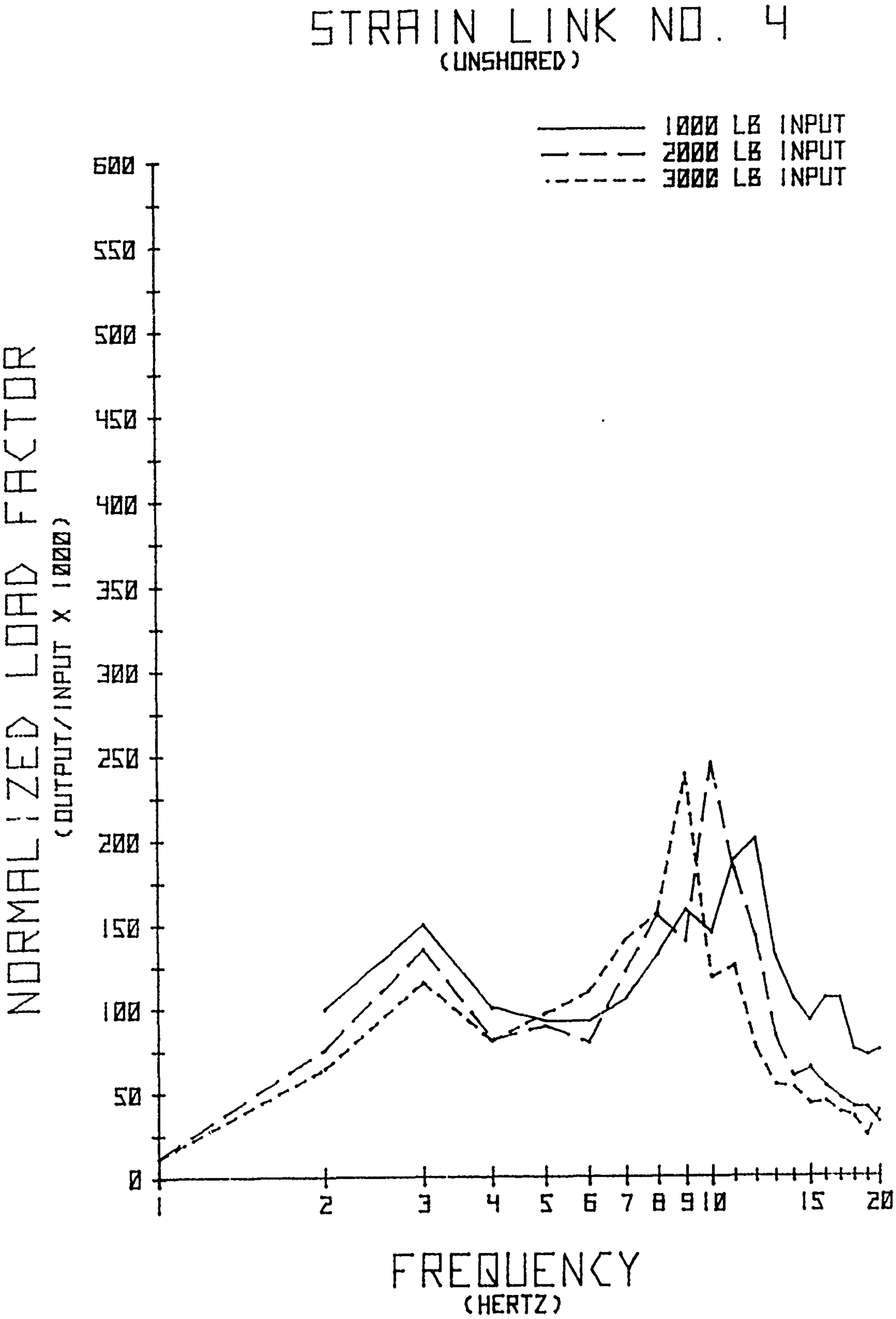
APPENDIX B

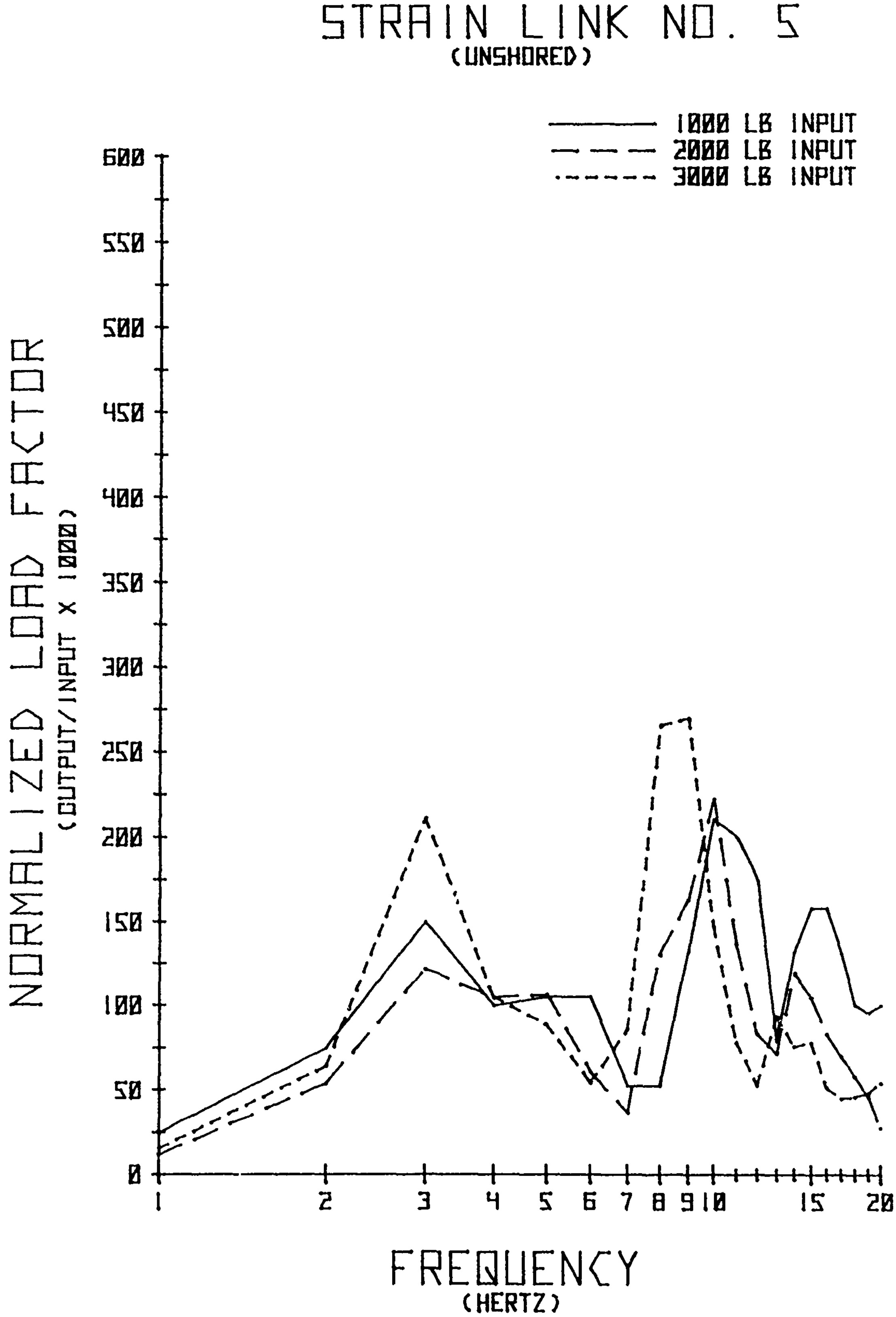
DATA PLOTS WITHOUT RAIL SETS

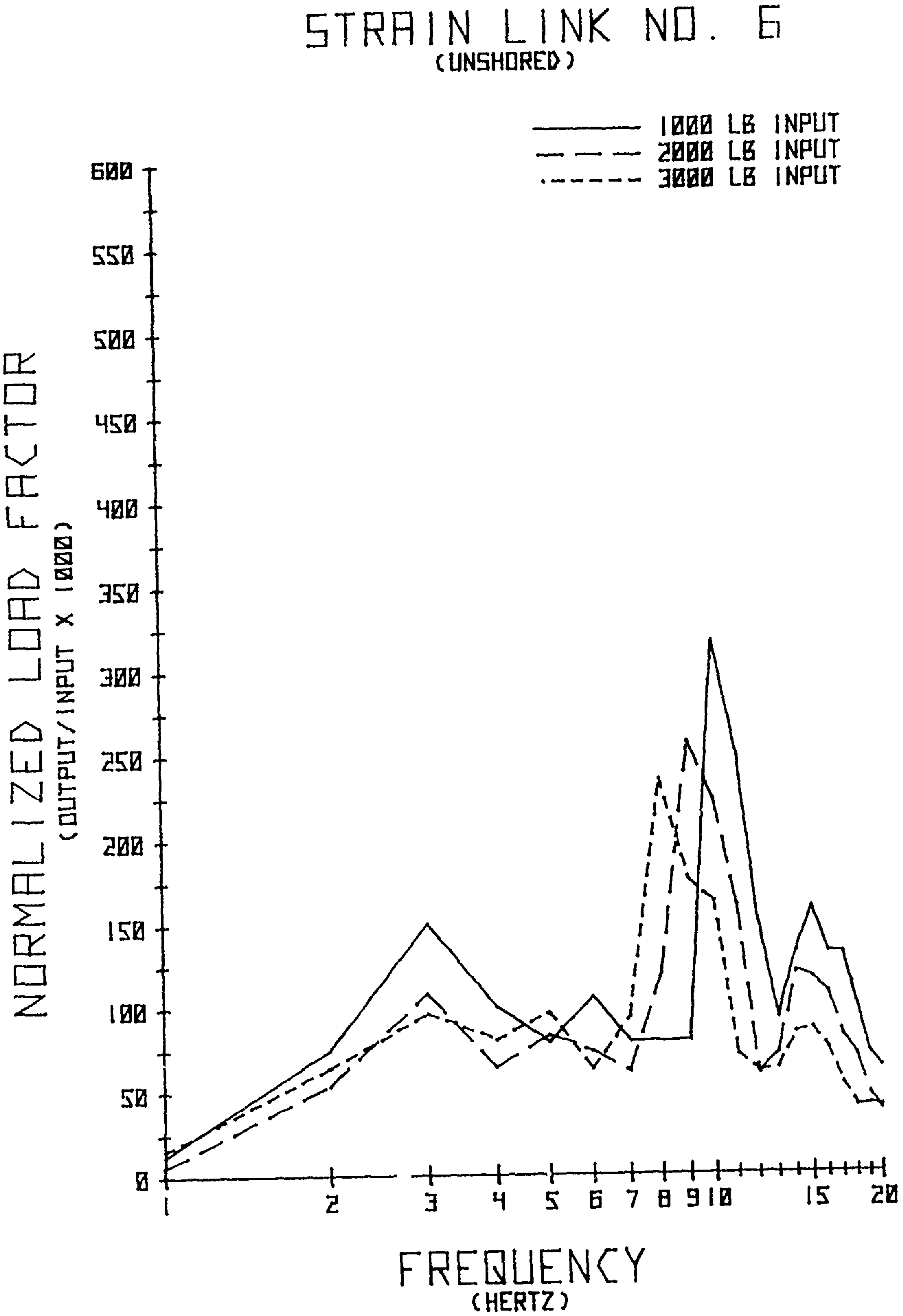

STRAIN LINK NO. 1
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

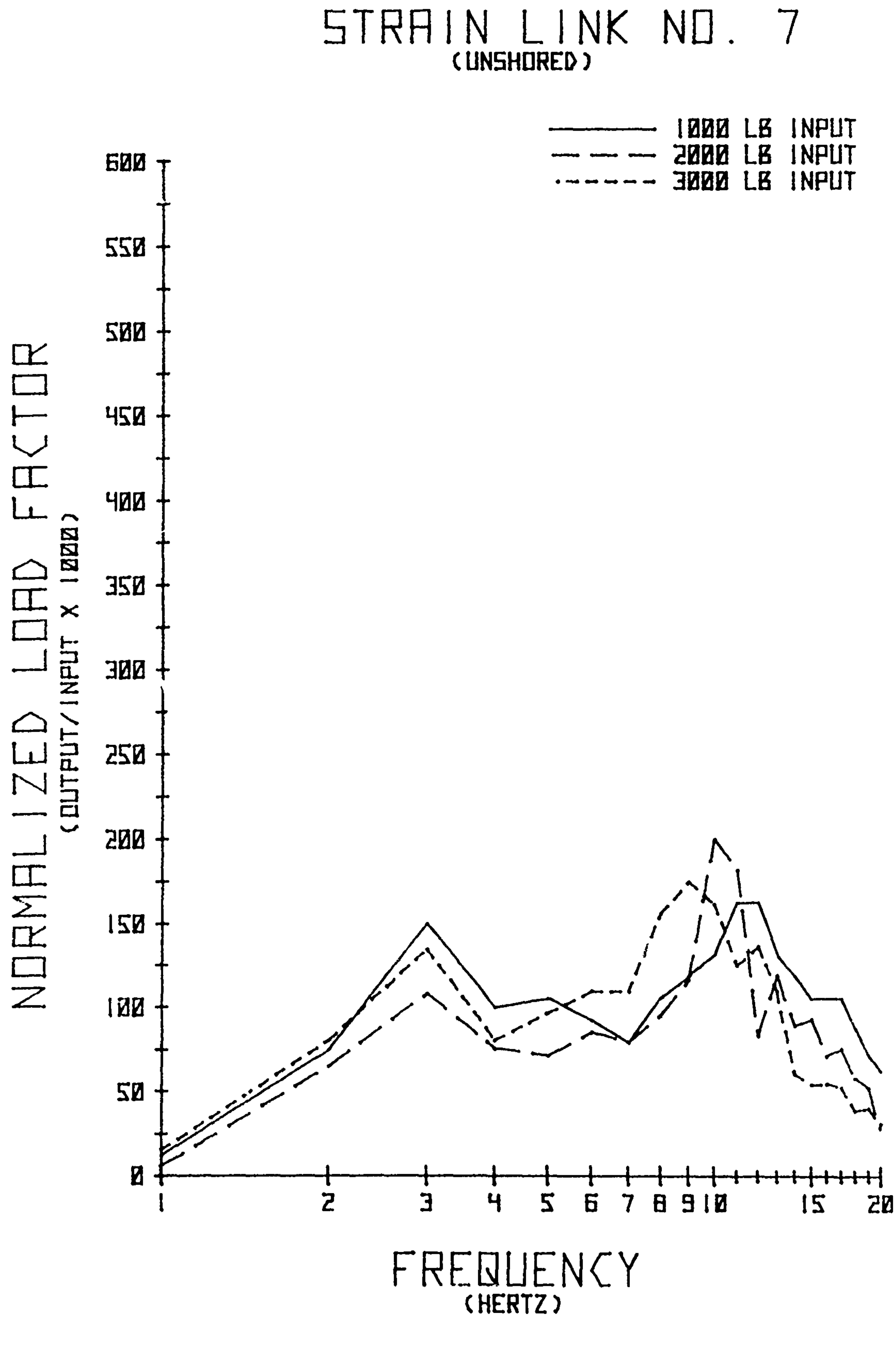

STRAIN LINK NO. 2
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

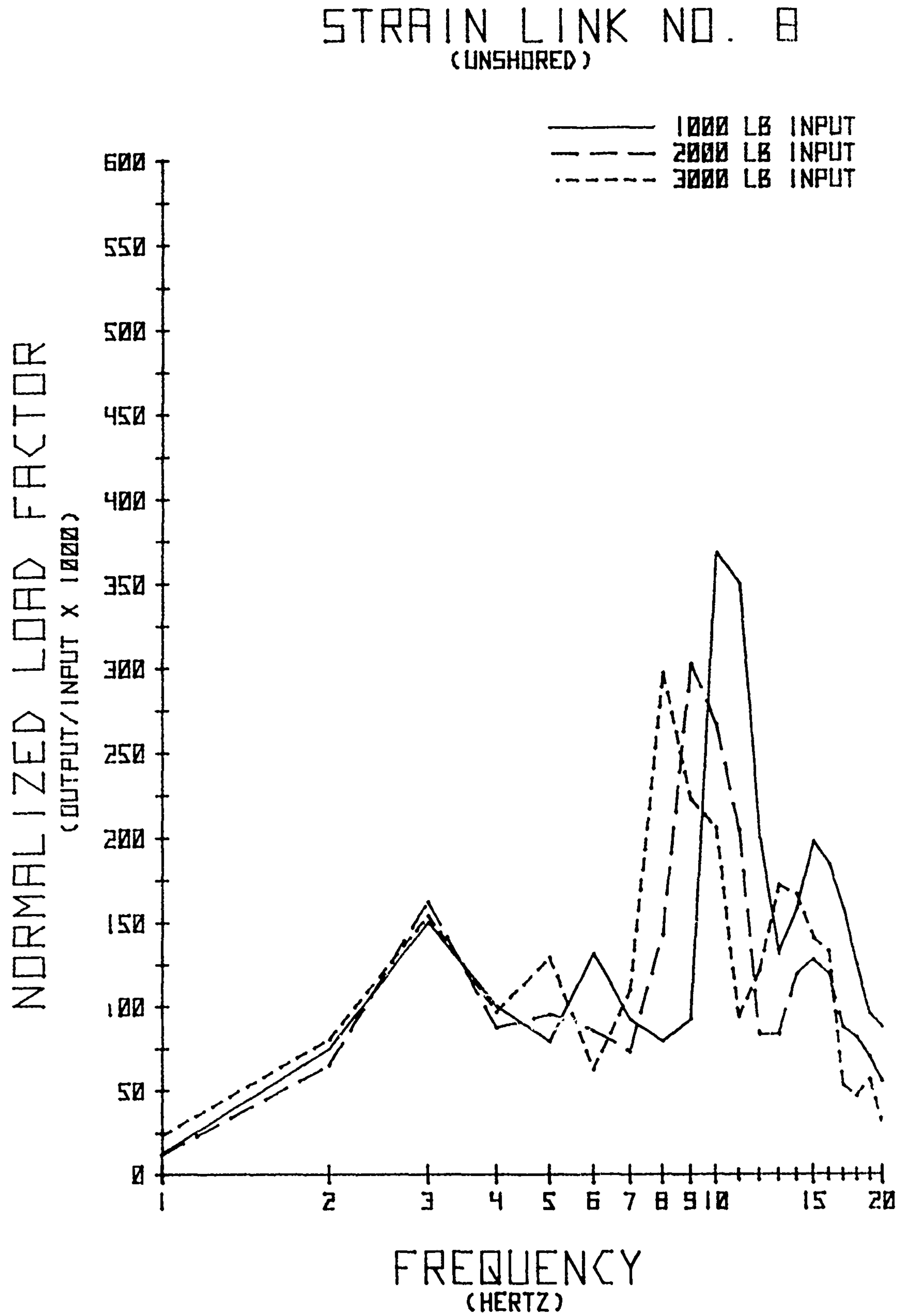

STRAIN LINK NO. 3
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

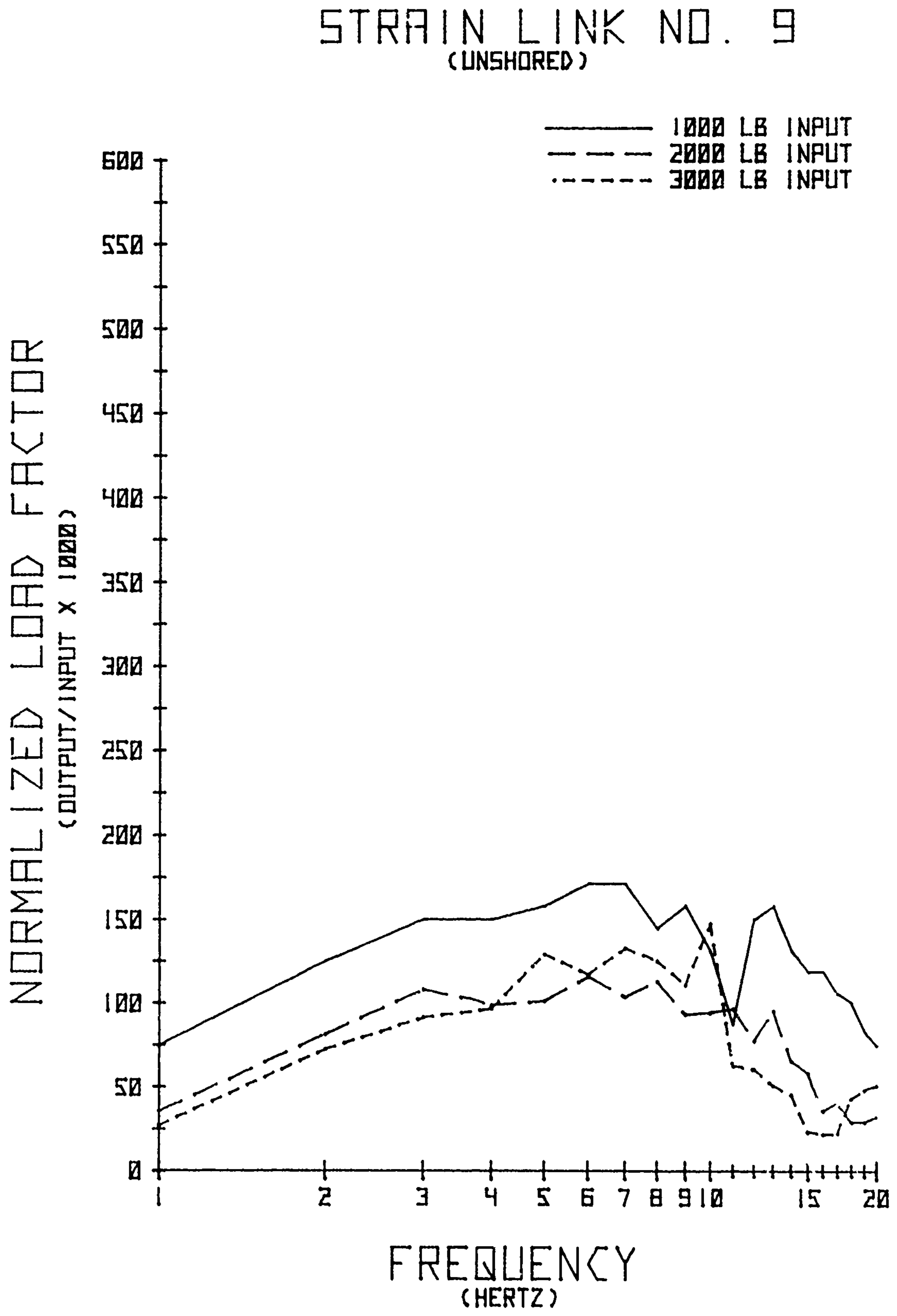

STRAIN LINK NO. 4
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 5
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

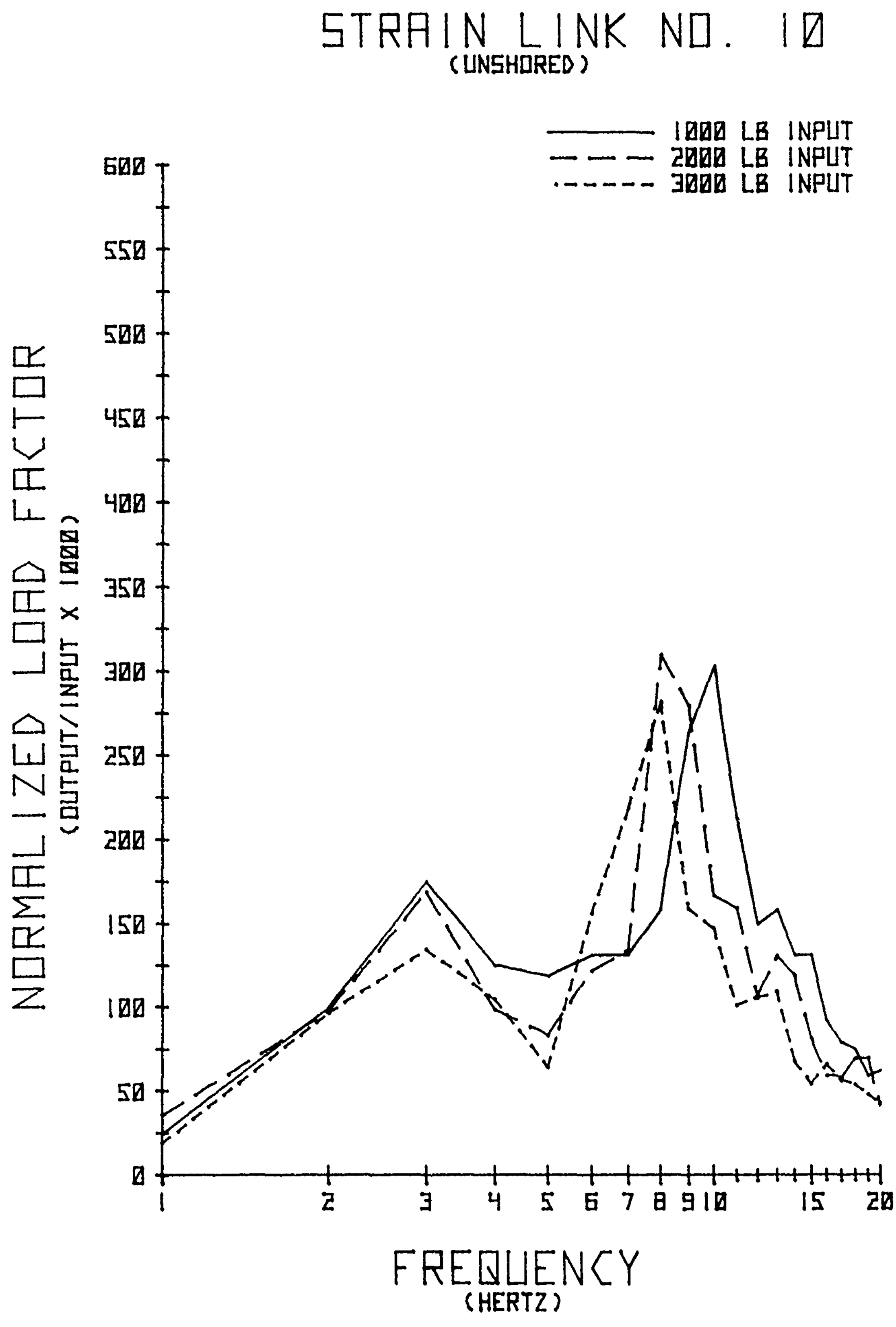

STRAIN LINK NO. 6
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 7
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

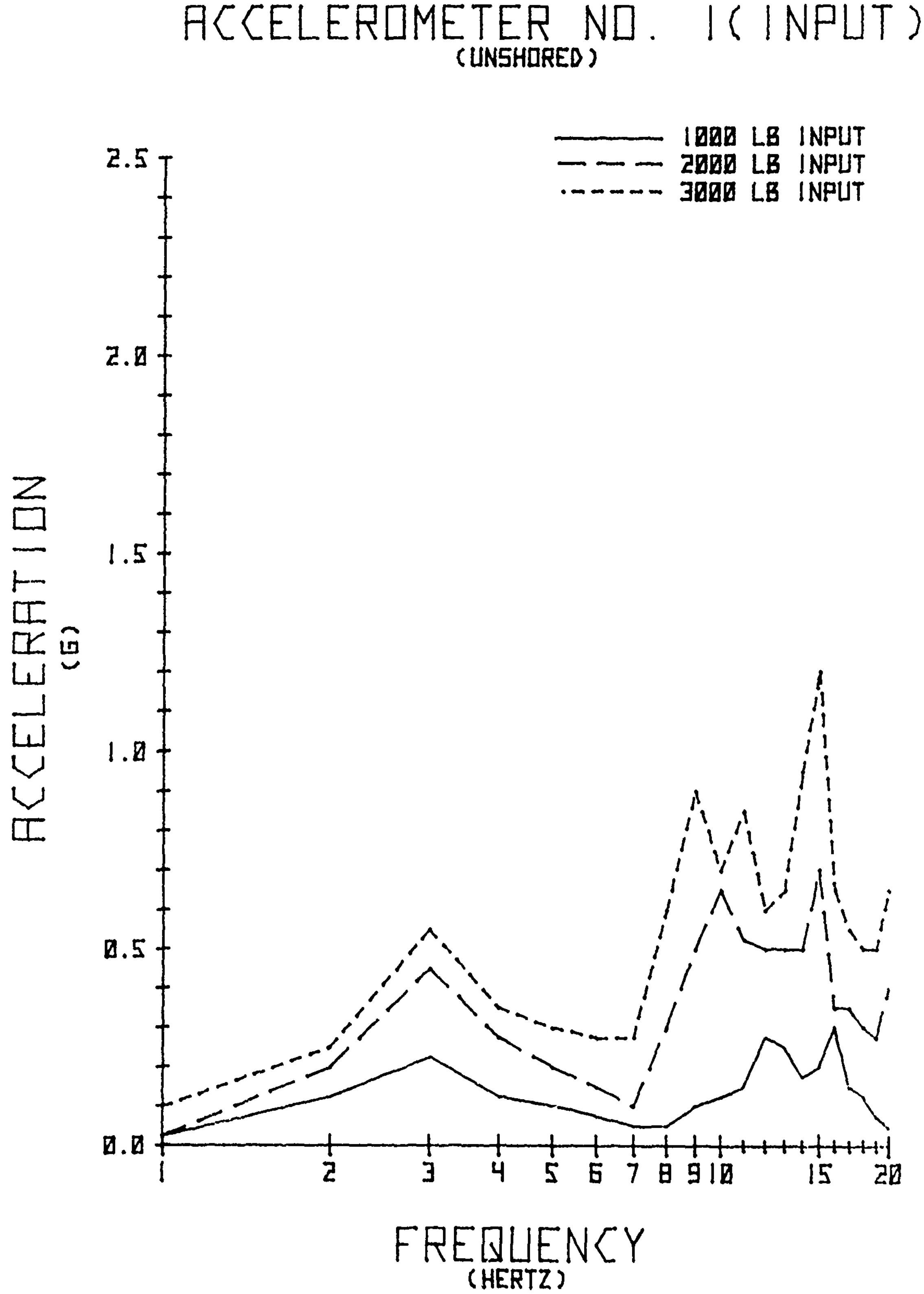

STRAIN LINK NO. 8
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

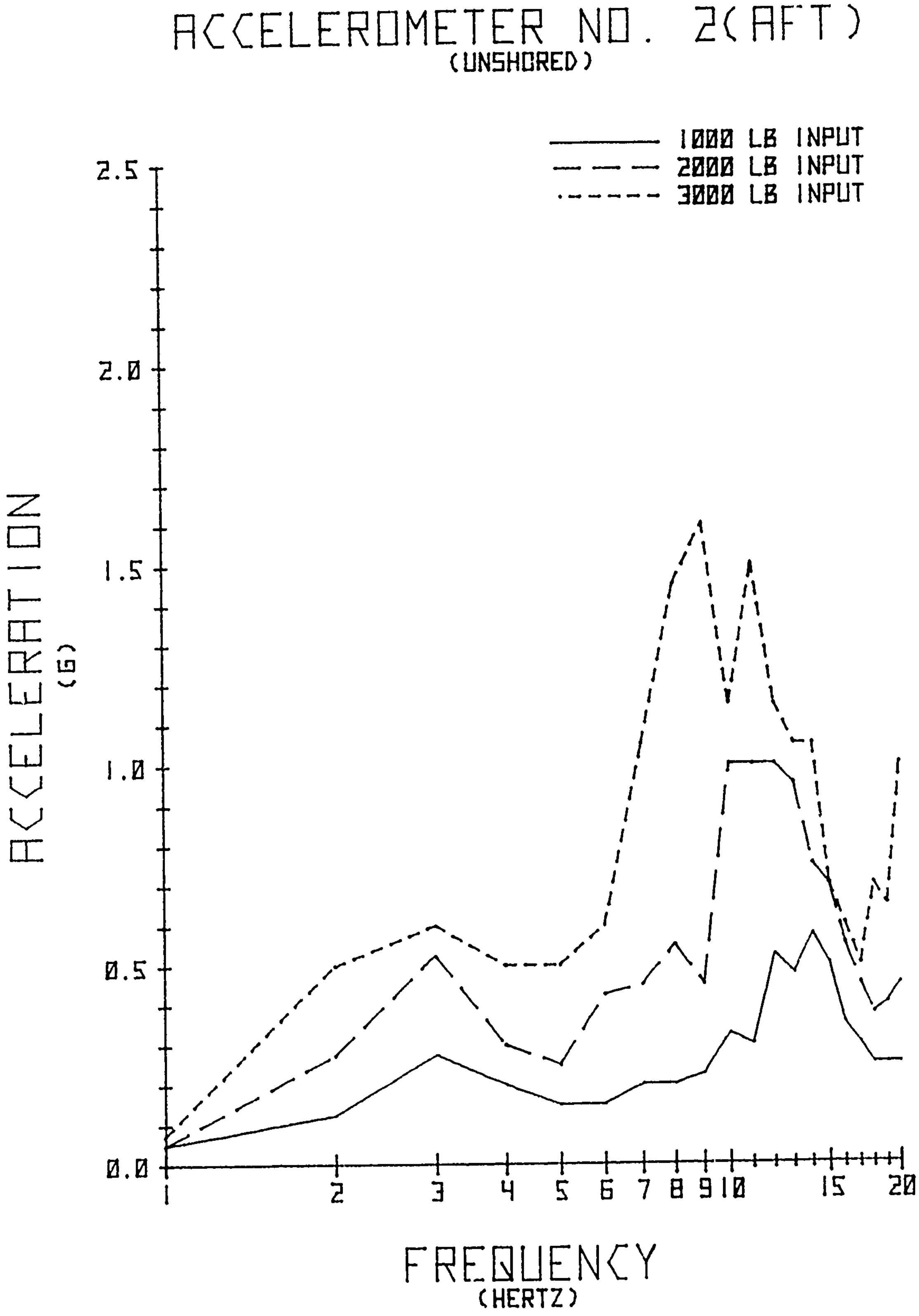


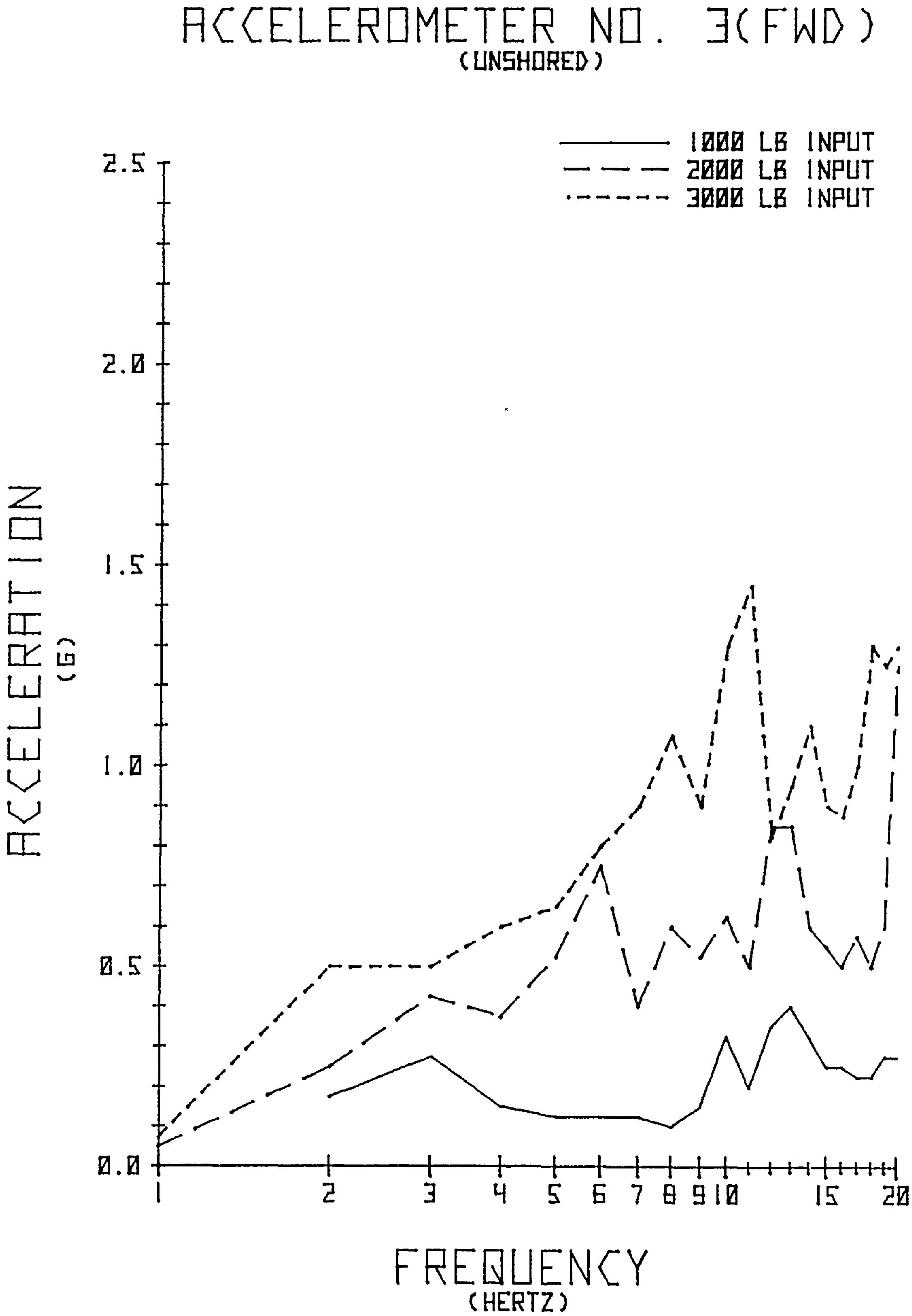
STRAIN LINK NO. 9
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

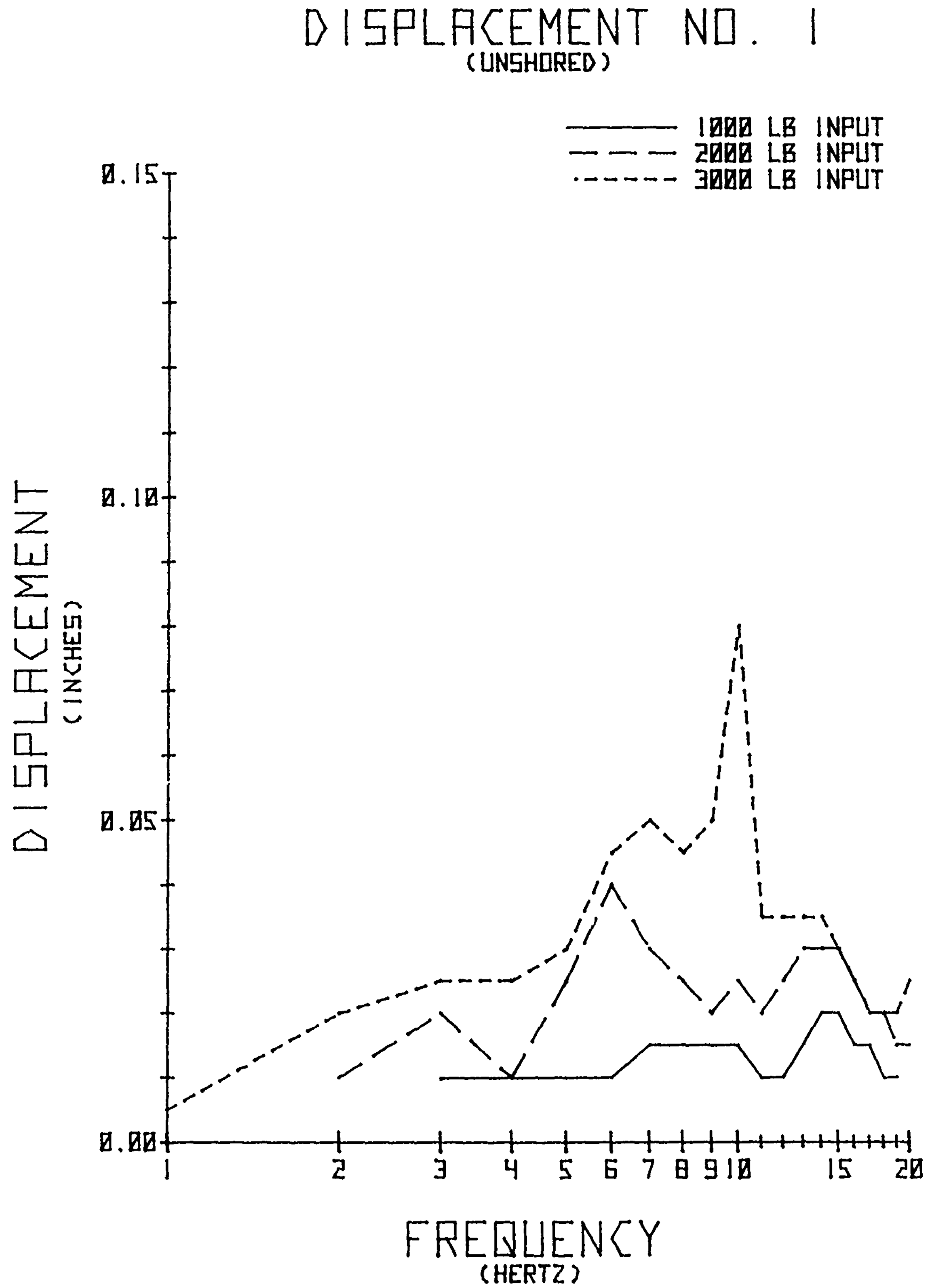


STRAIN LINK NO. 10
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

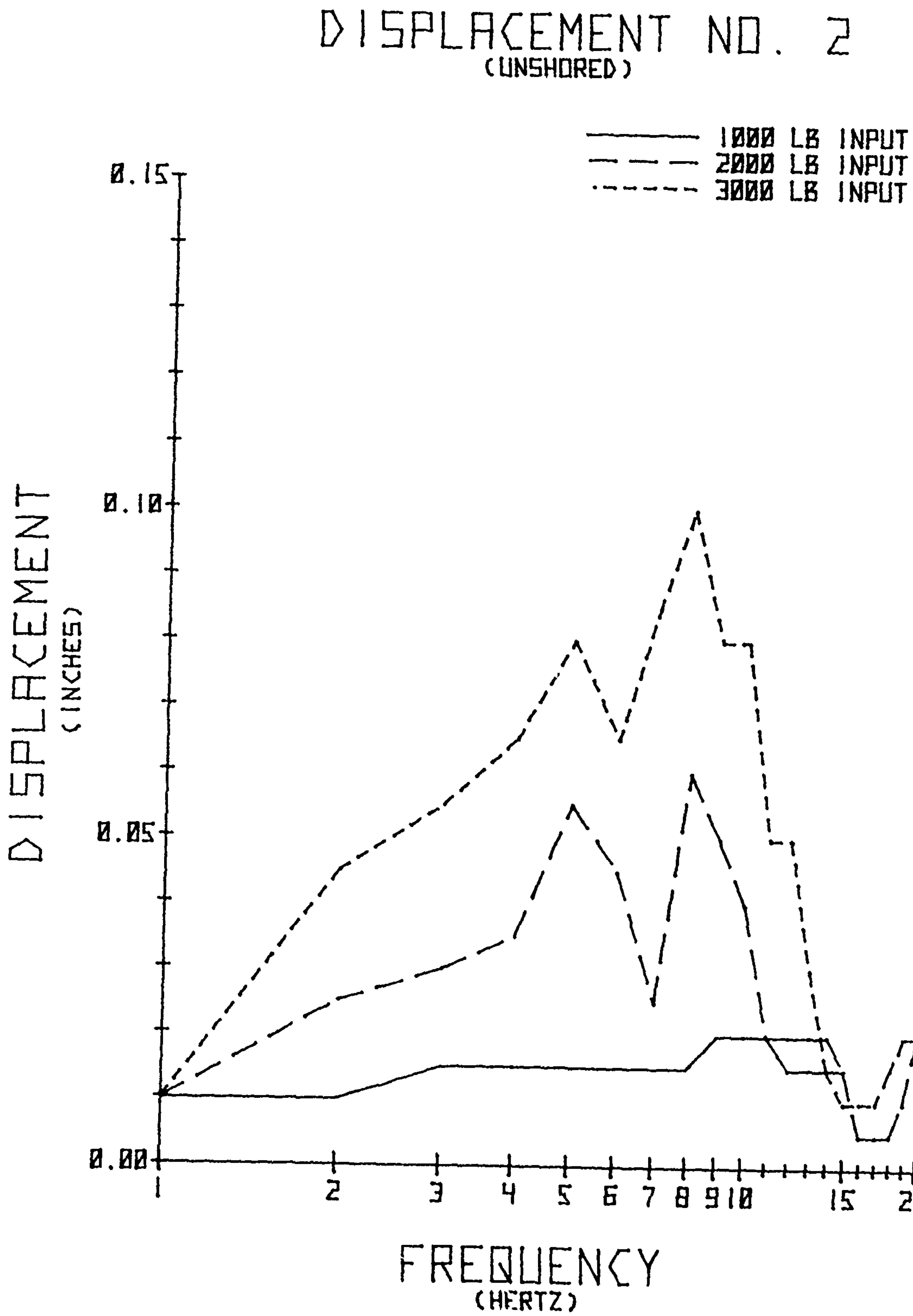

ACCELEROMETER NO. 1 (INPUT)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

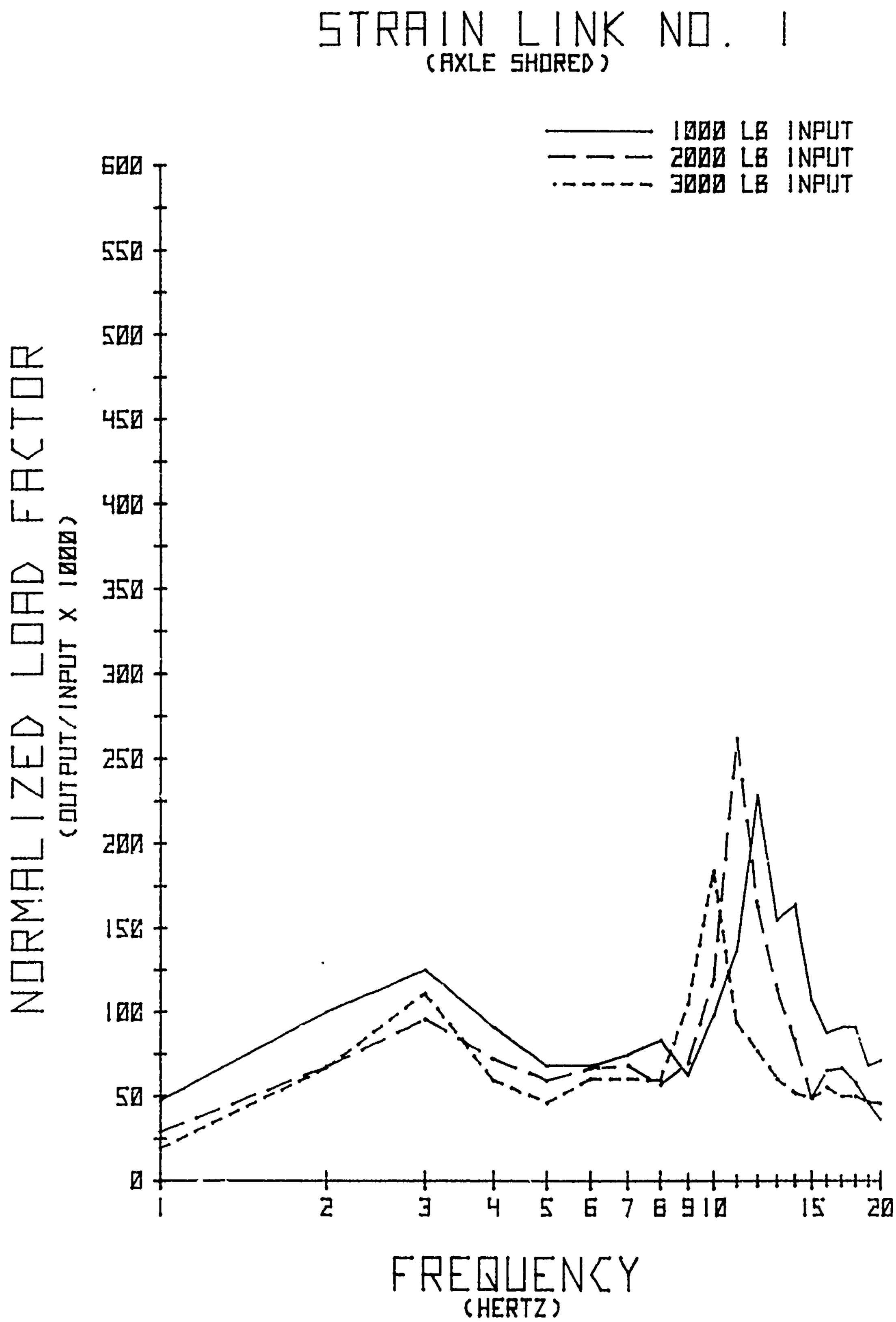

ACCELEROMETER NO. 2(AFT)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


ACCELEROMETER NO. 3(FWD)
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

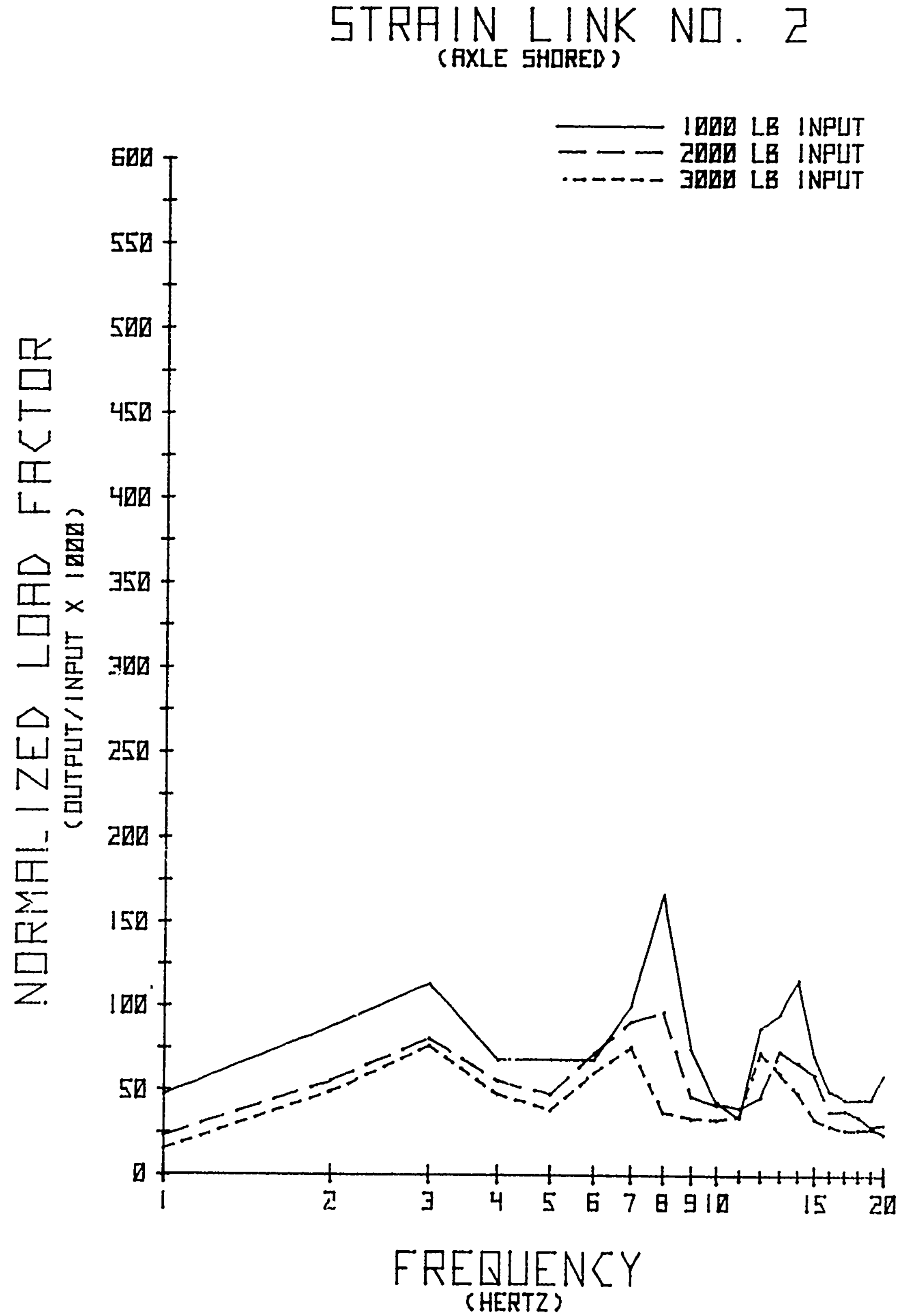


DISPLACEMENT NO. 1
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


DISPLACEMENT NO. 2
(UNSHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

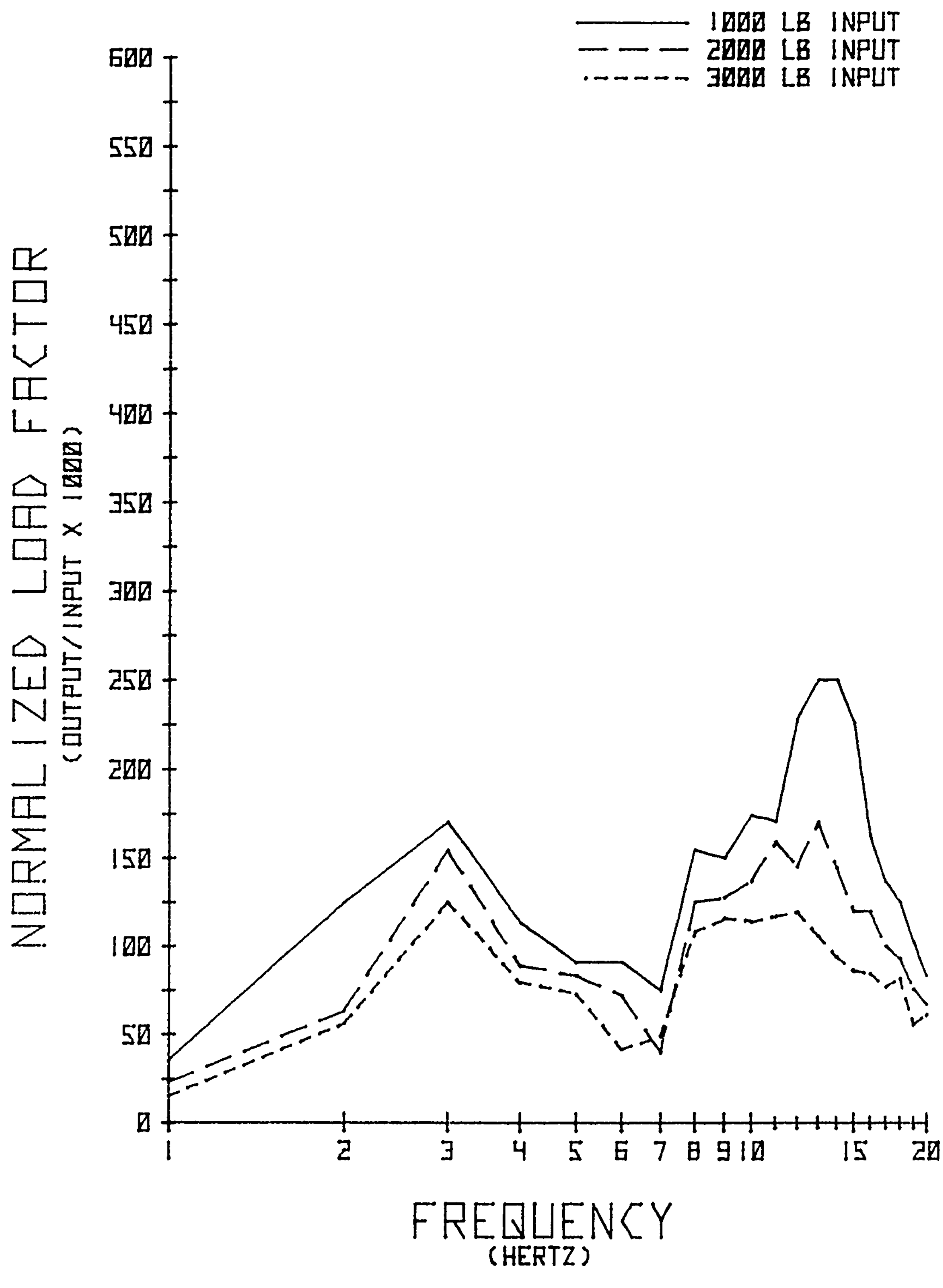


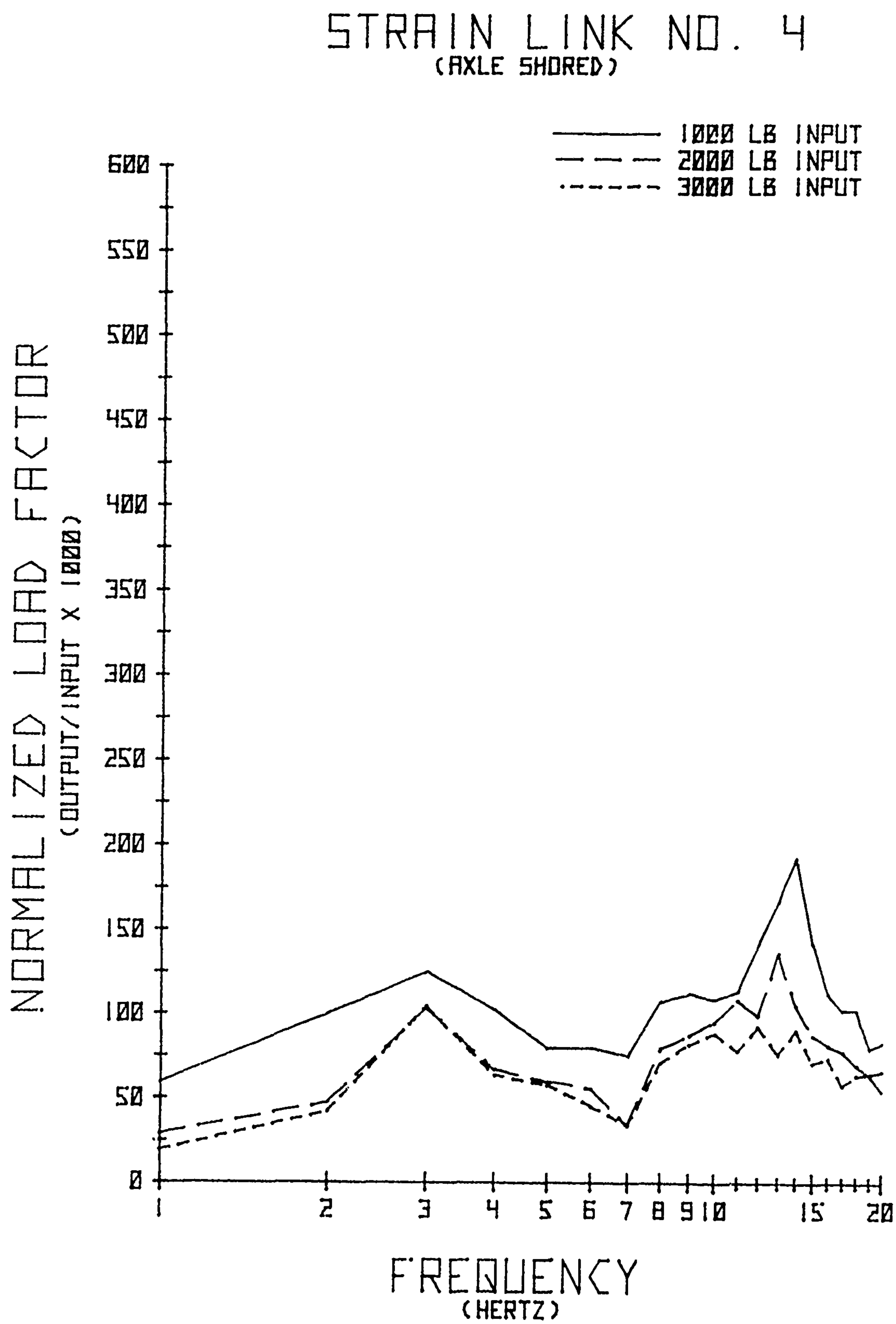
STRAIN LINK NO. 1
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

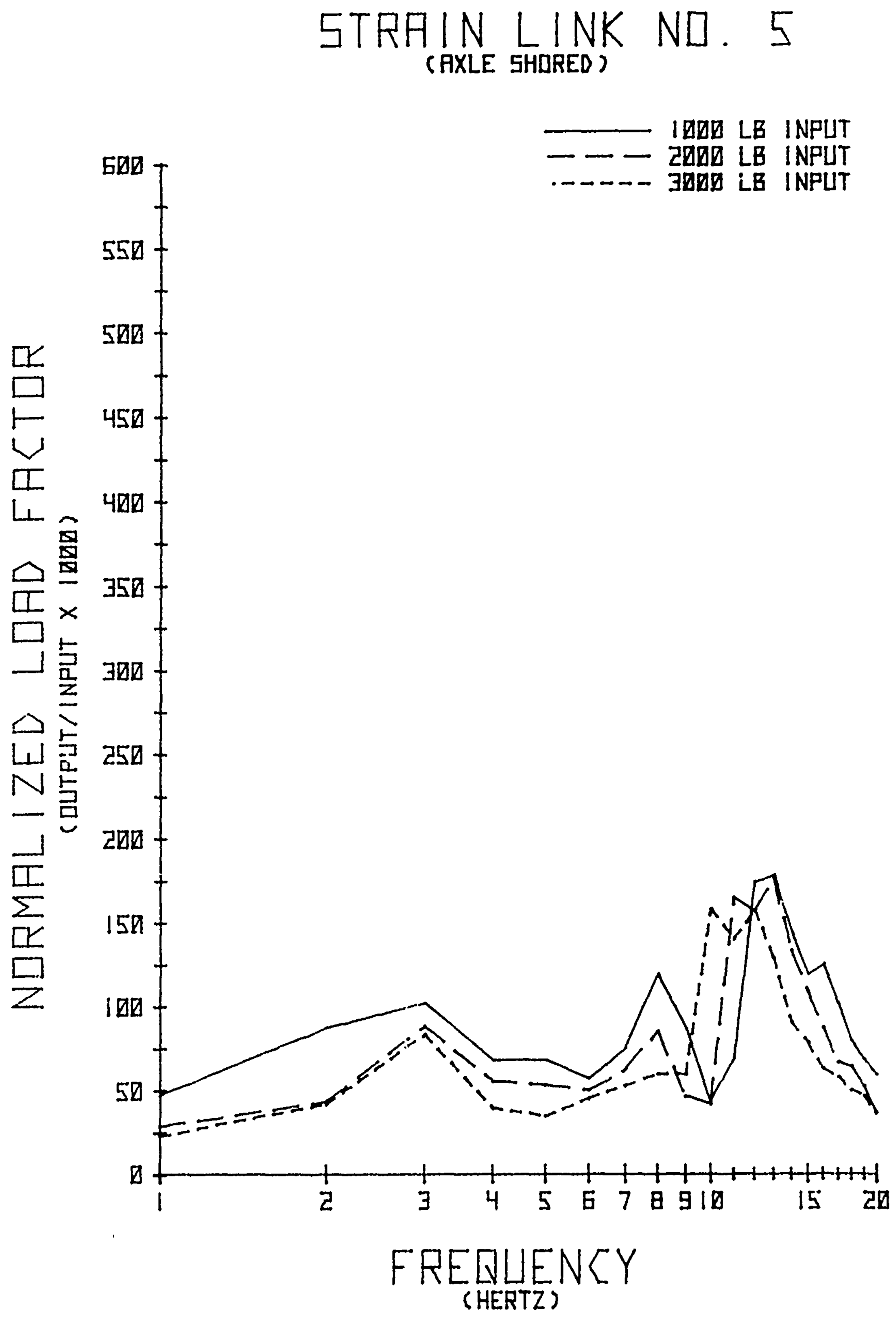


STRAIN LINK NO. 2
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

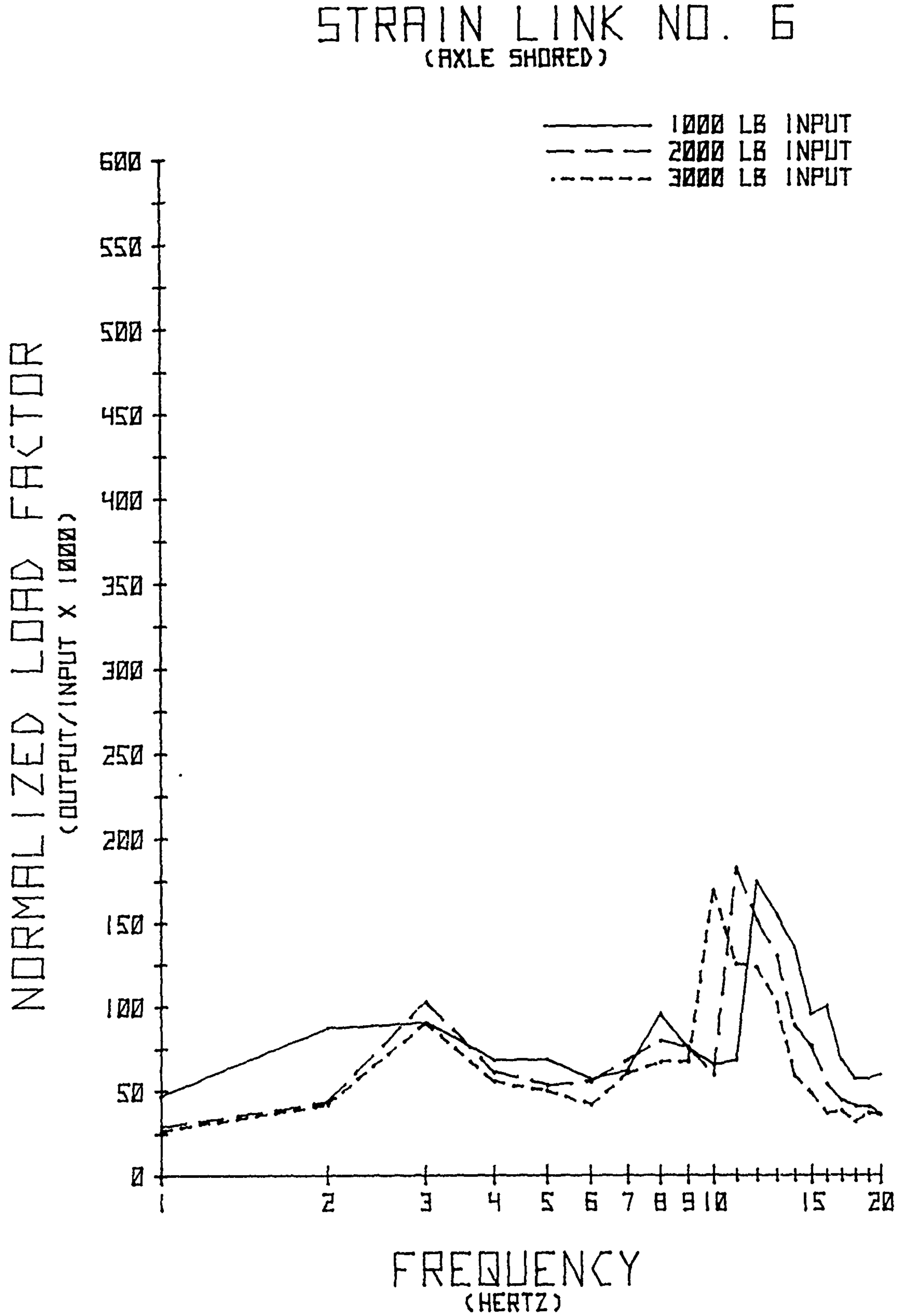
STRAIN LINK NO. 3
(AXLE SHORED)



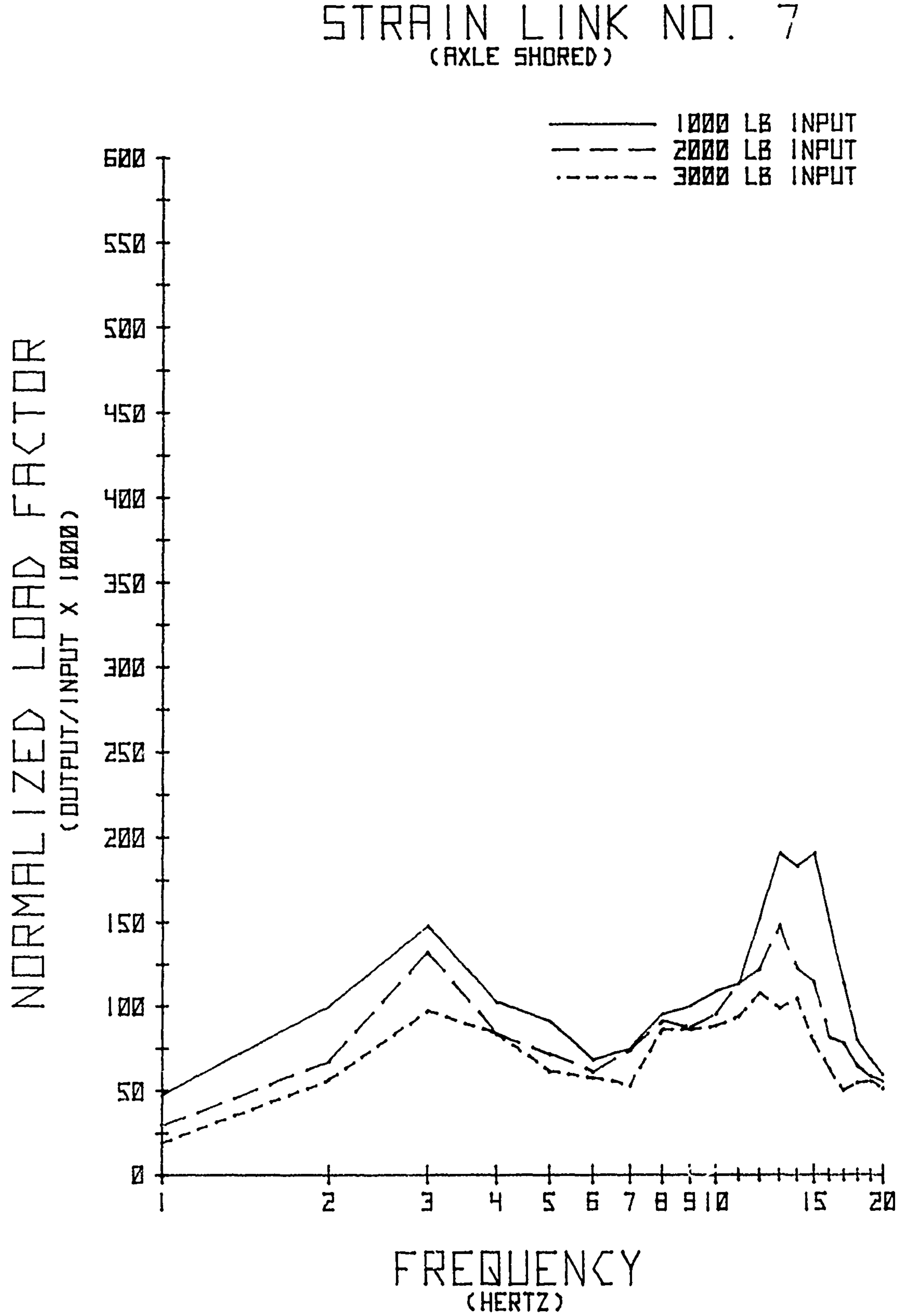

STRAIN LINK NO. 4
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

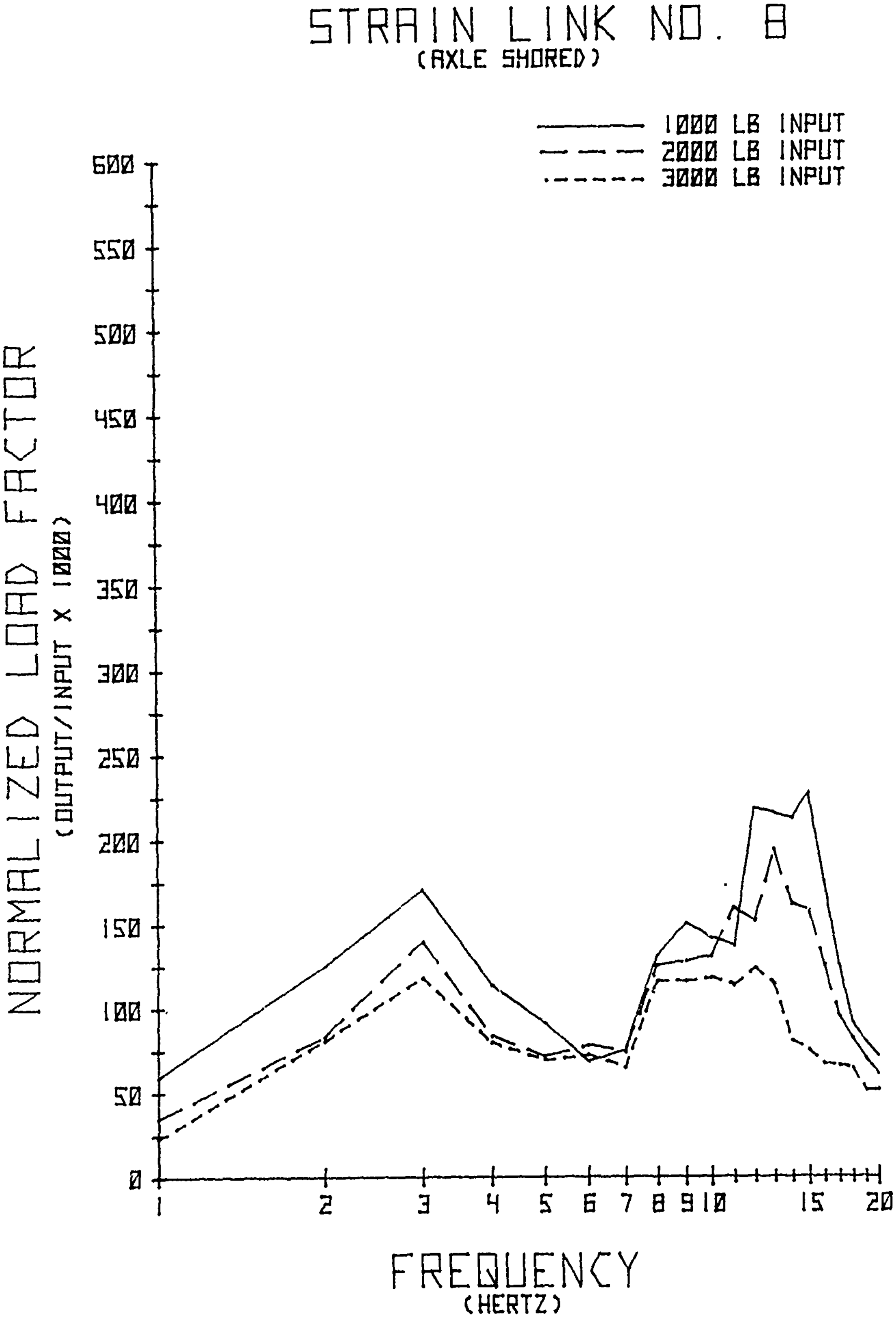


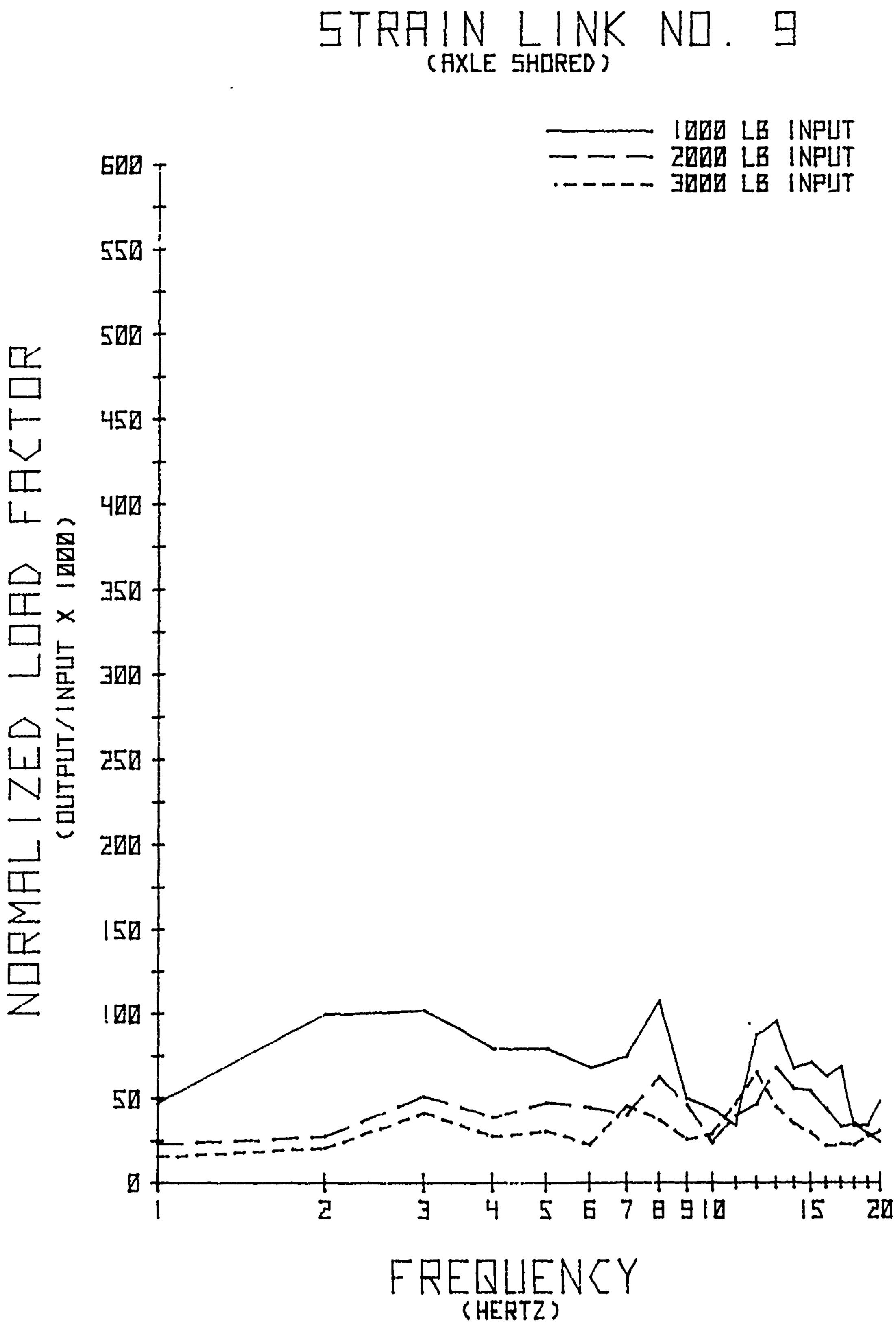
STRAIN LINK NO. 5
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

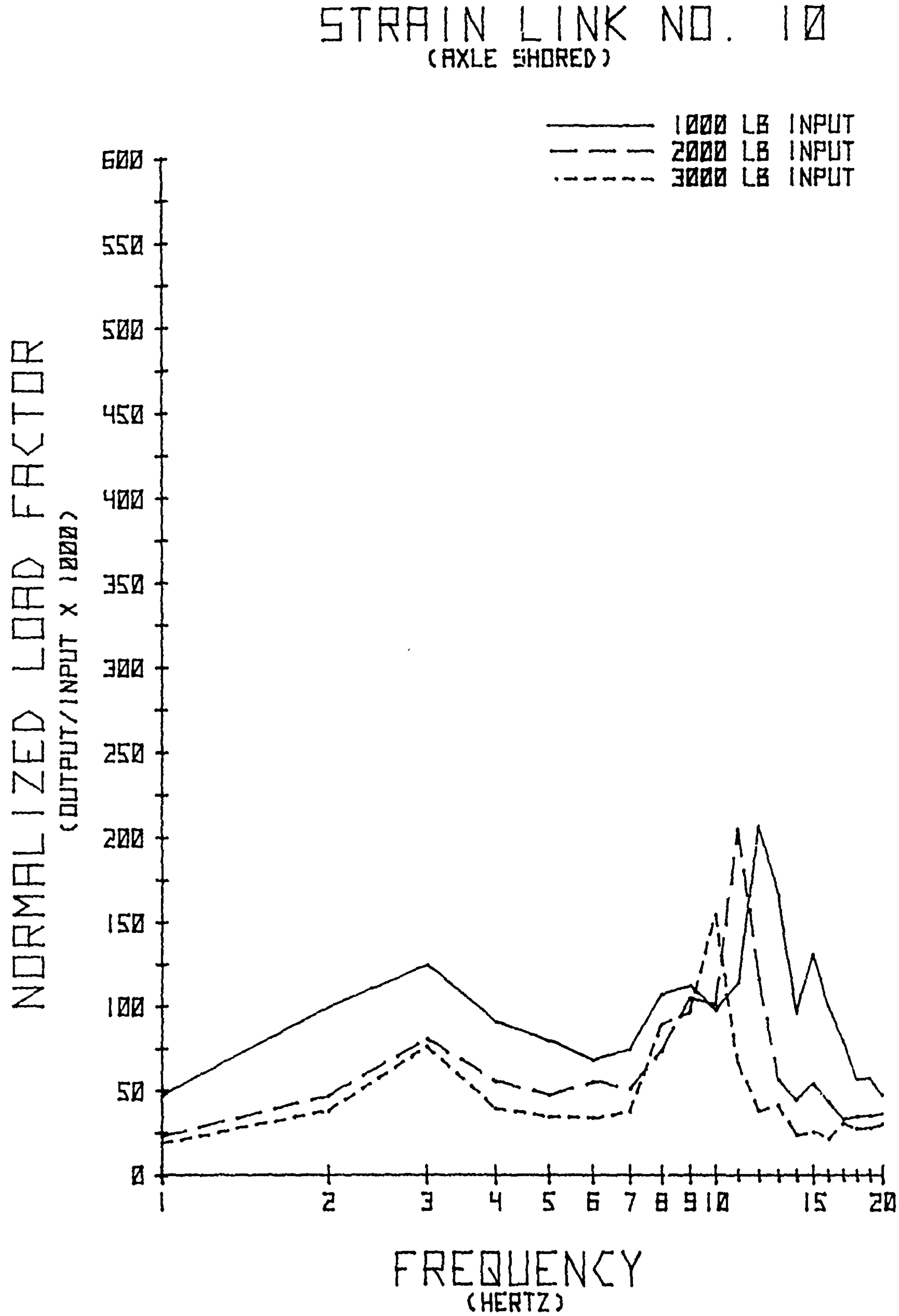


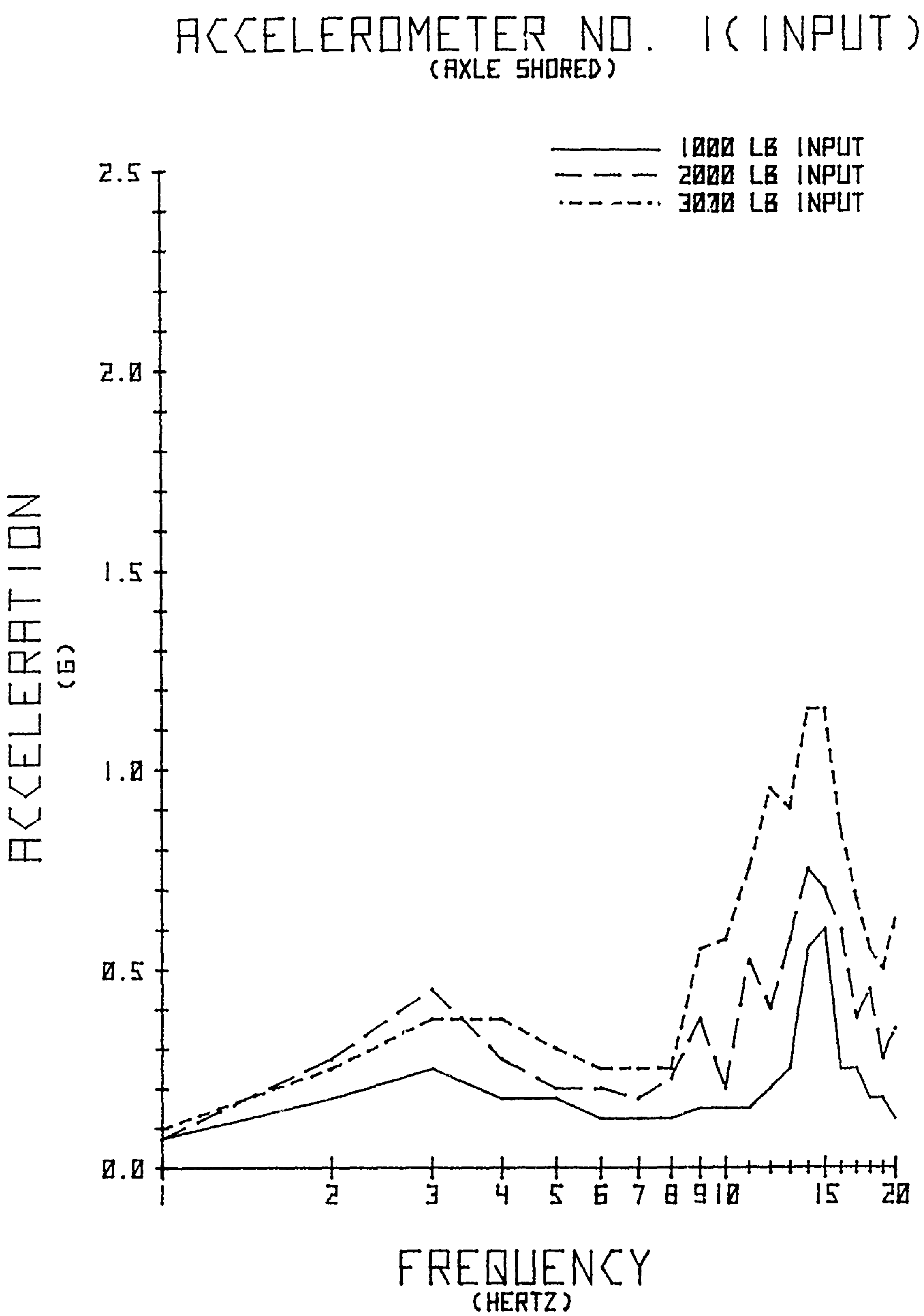
STRAIN LINK NO. 6
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

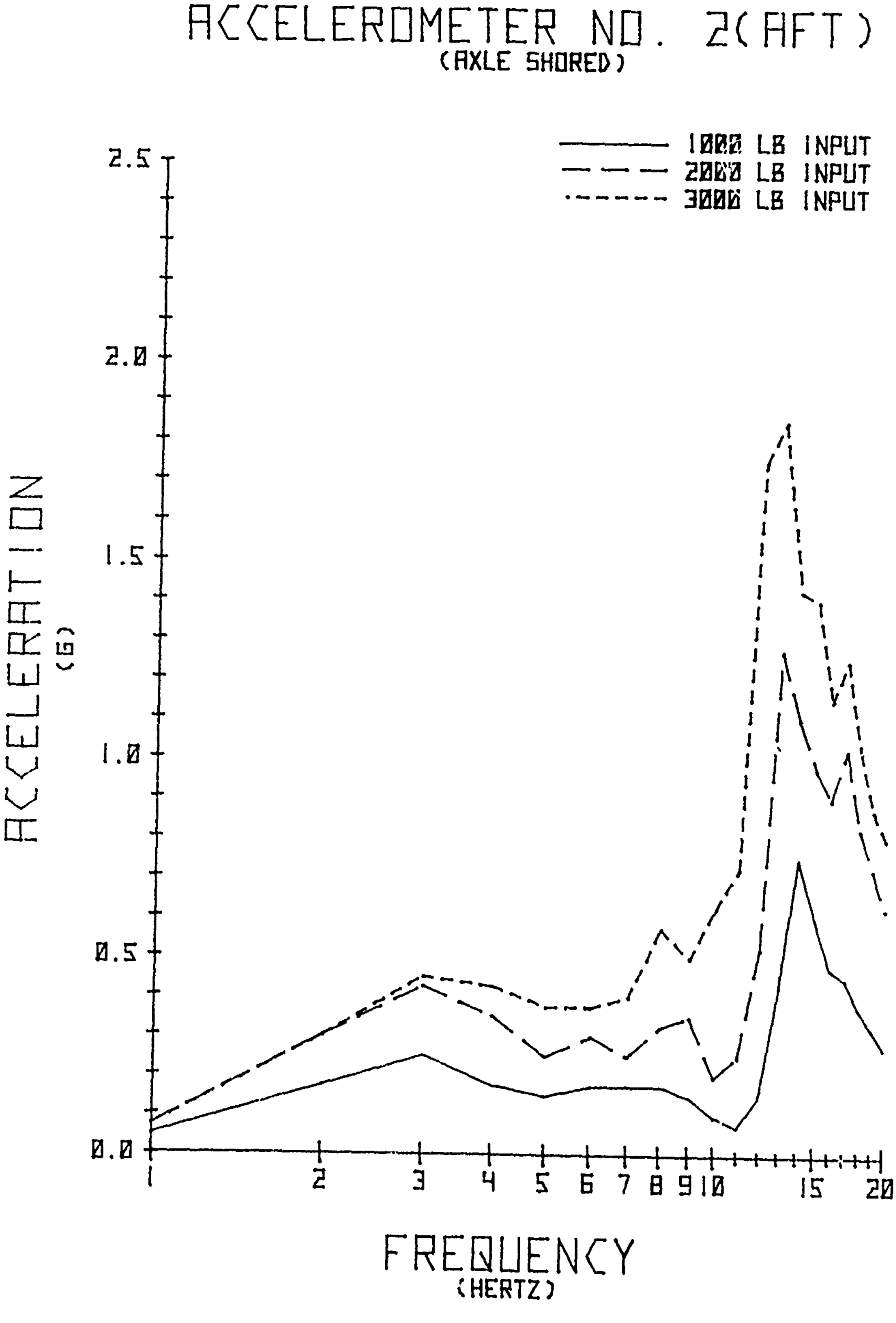

STRAIN LINK NO. 7
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

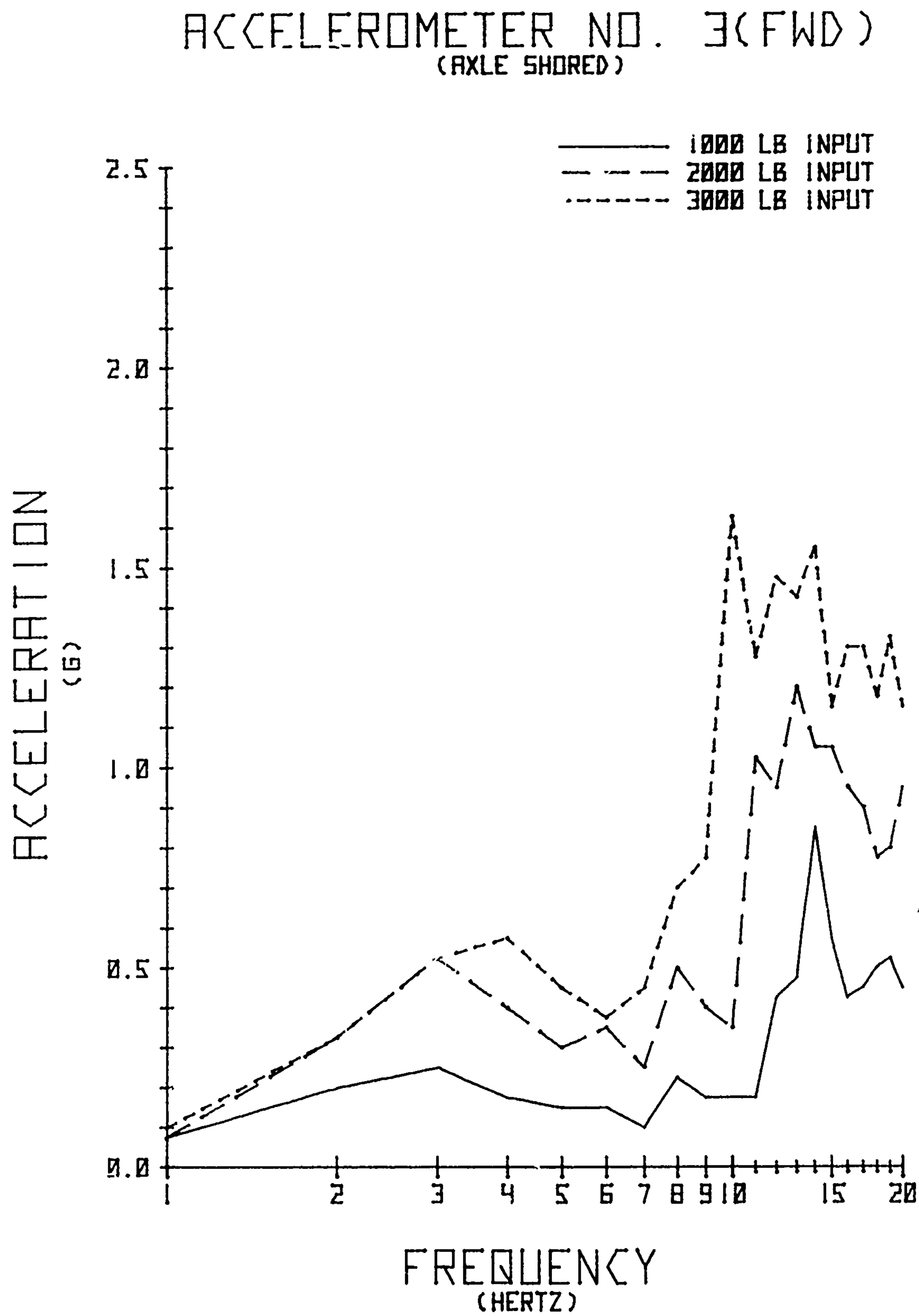

STRAIN LINK NO. 8
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 9
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

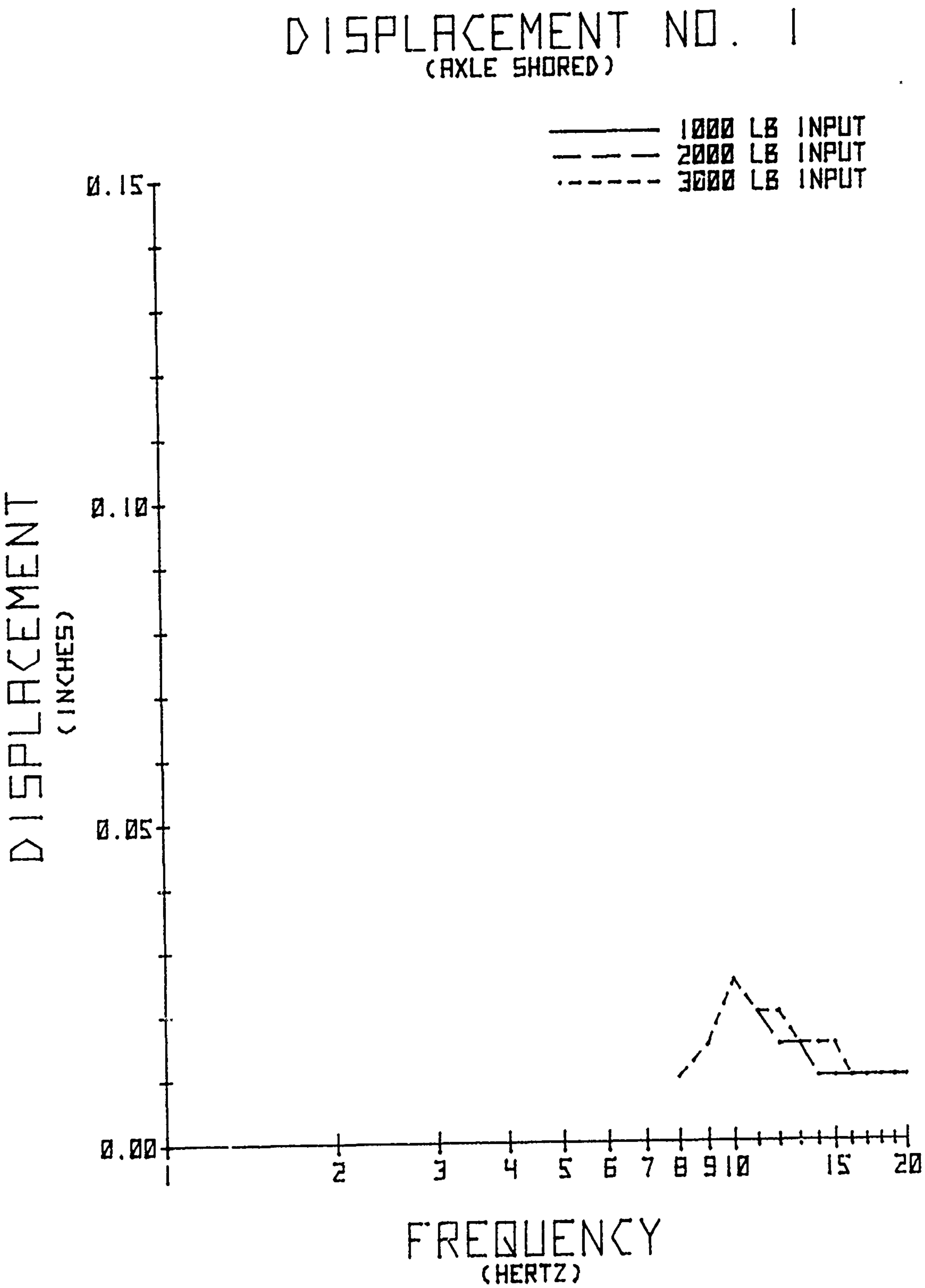

STRAIN LINK NO. 10
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

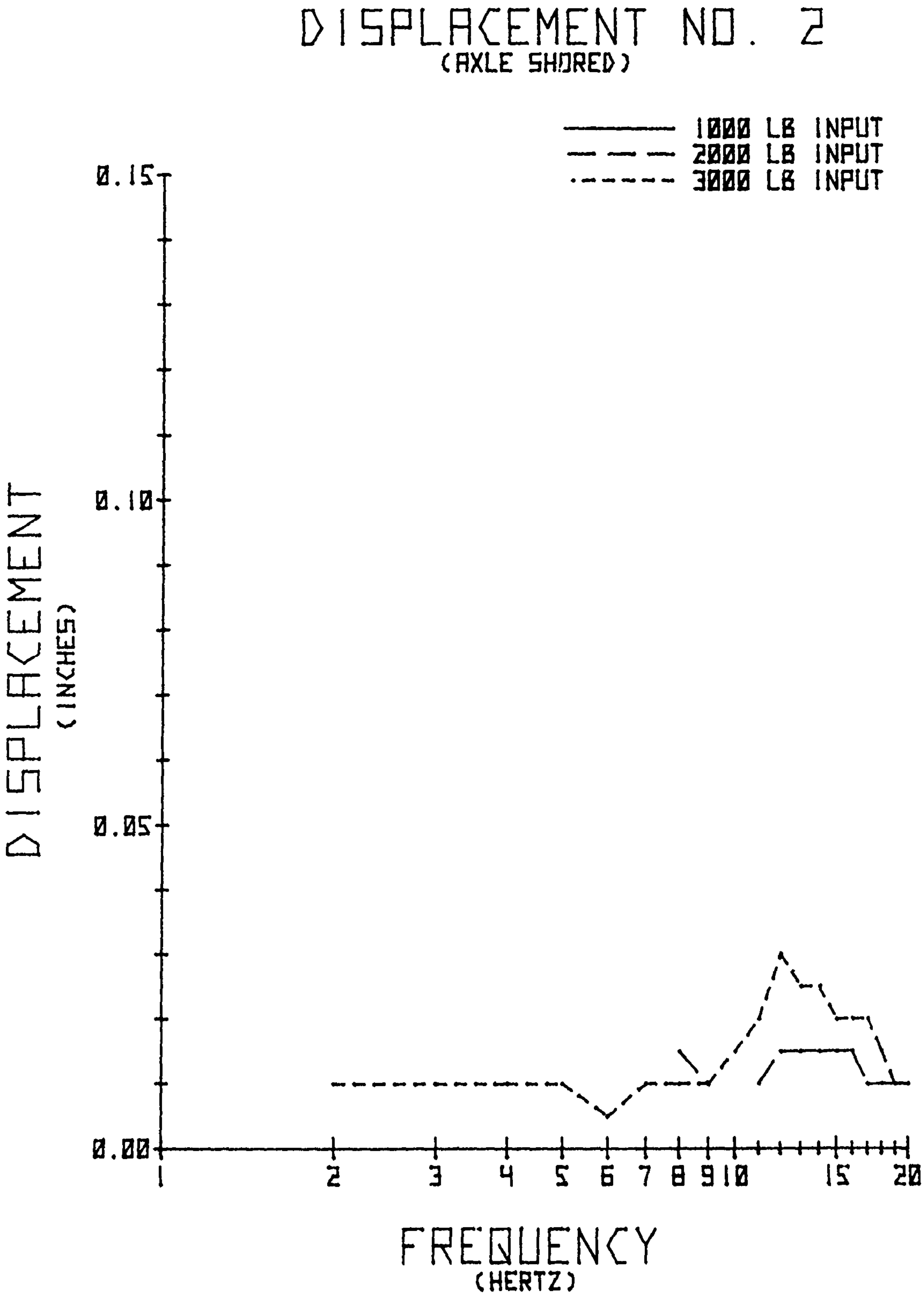

ACCELEROMETER NO. 1(INPUT)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3030 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

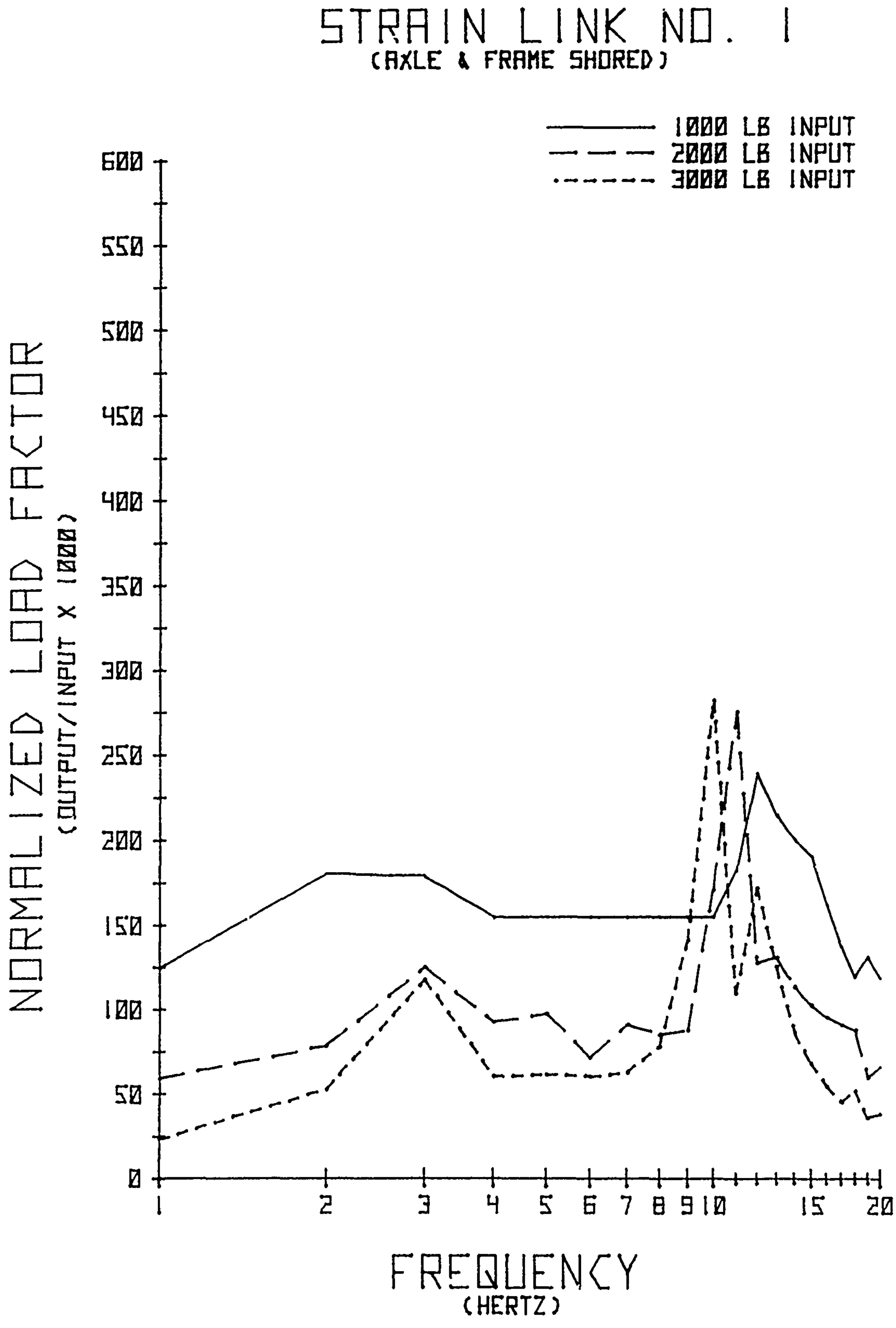

ACCELEROMETER NO. 2(AFT)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

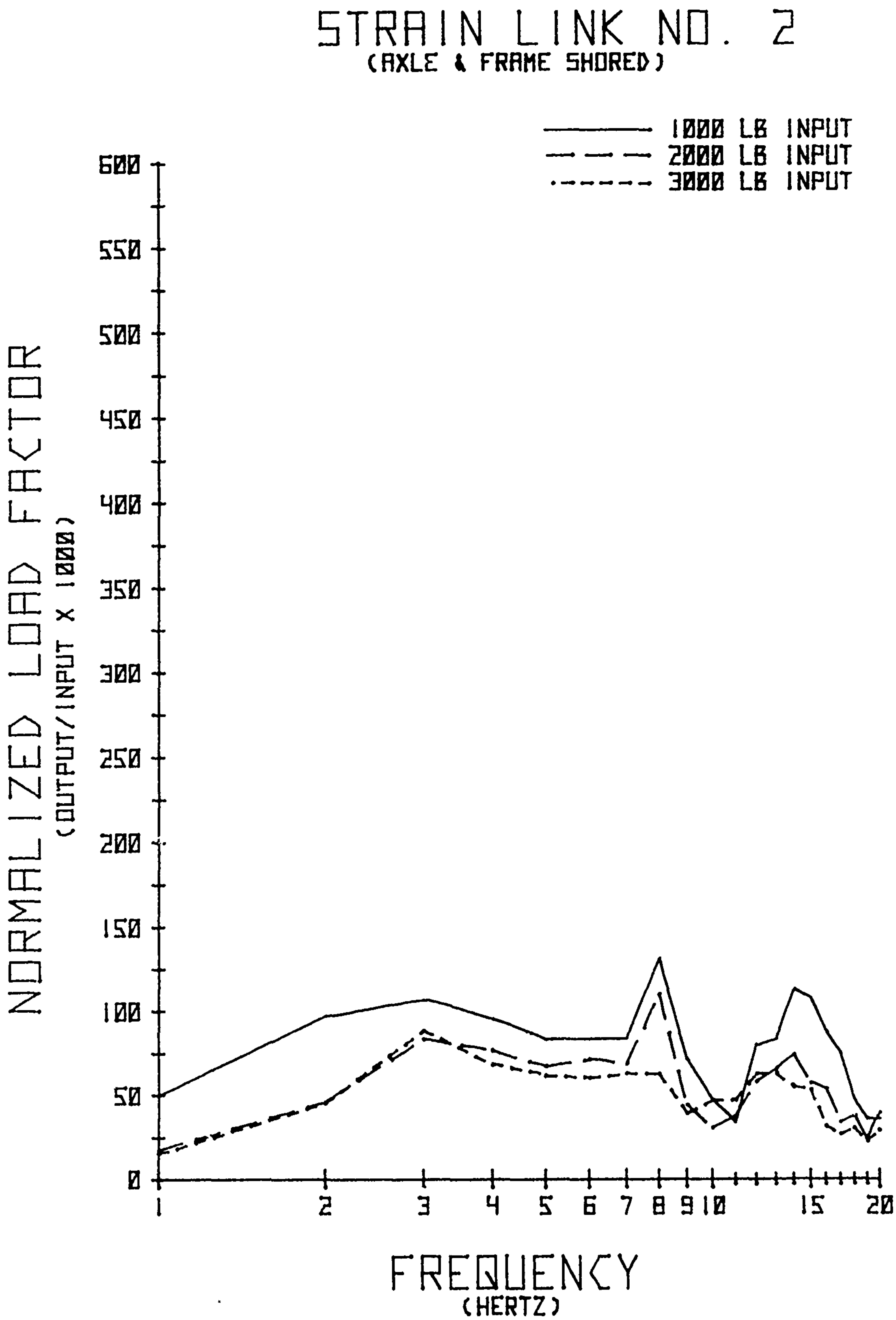


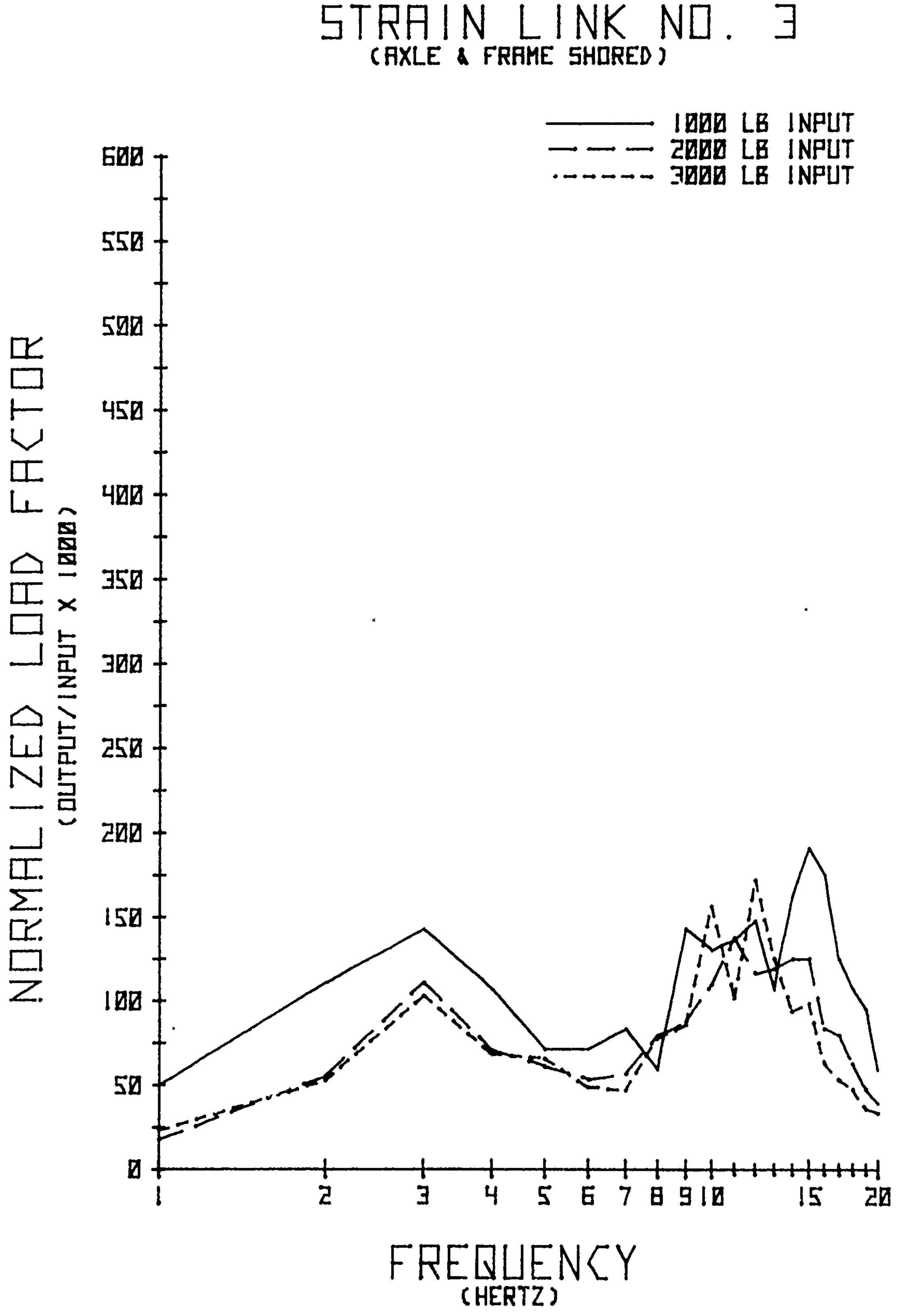
ACCELEROMETER NO. 3(FWD)
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

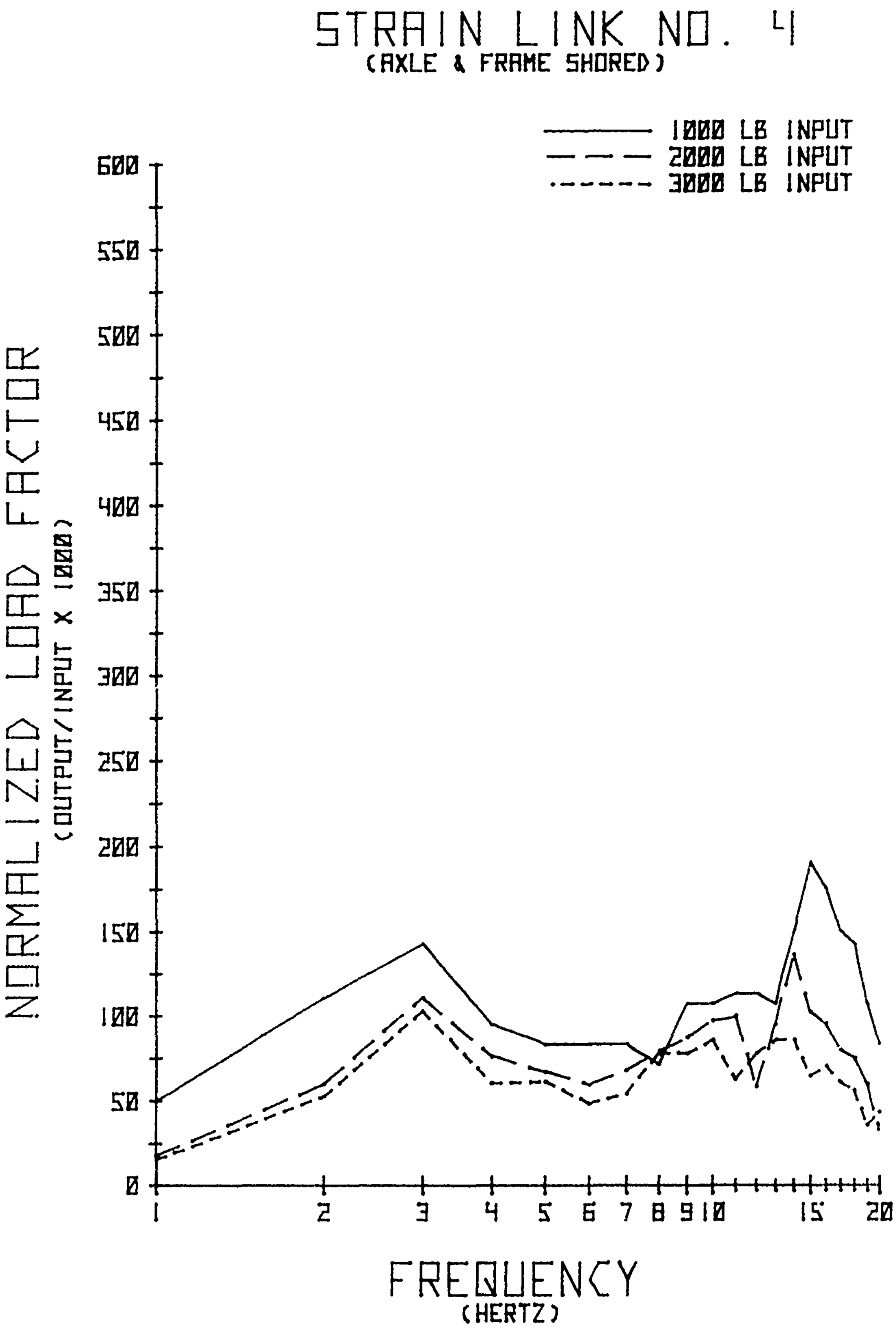

DISPLACEMENT NO. 1
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


DISPLACEMENT NO. 2
(AXLE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

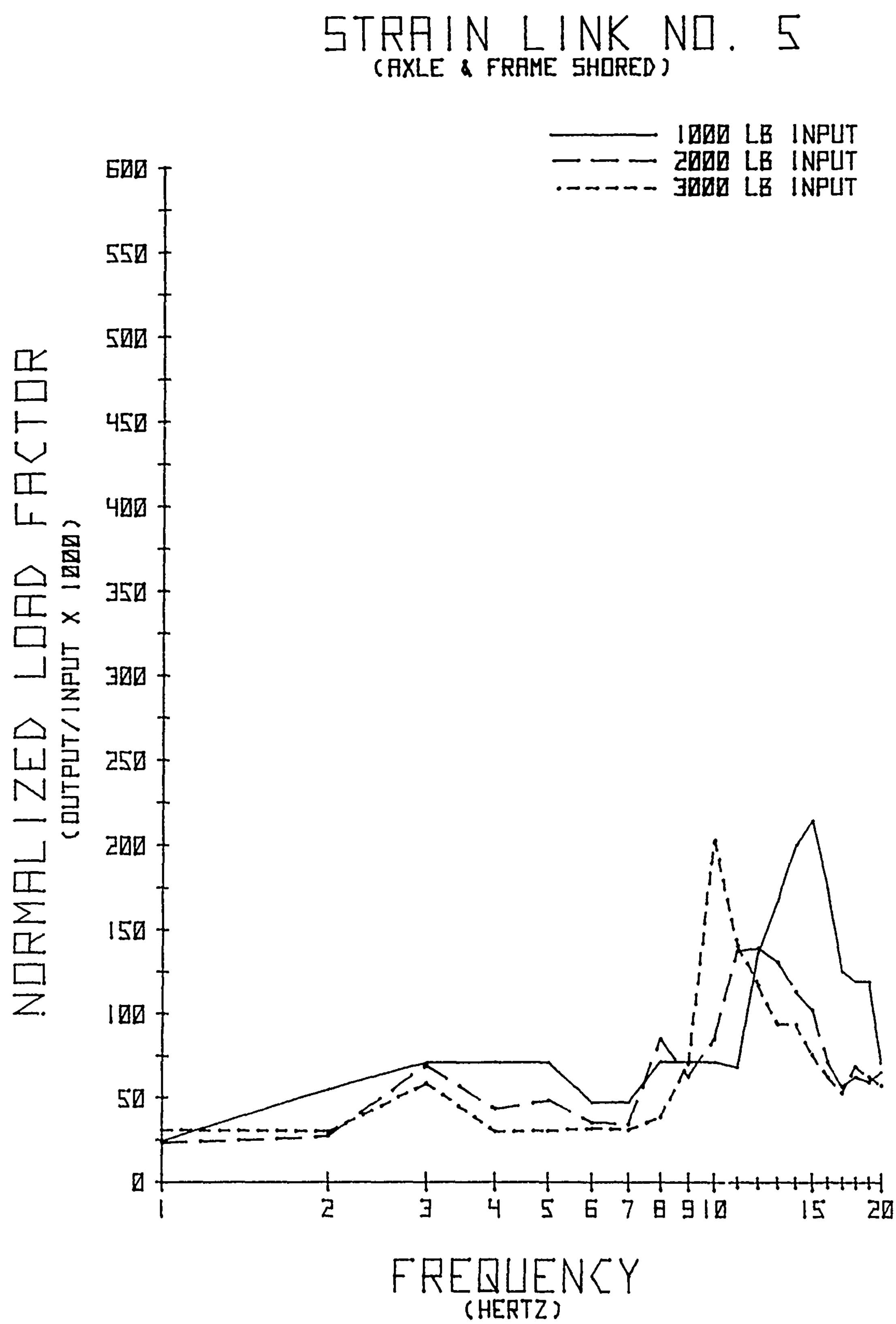

STRAIN LINK NO. 1
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 2
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

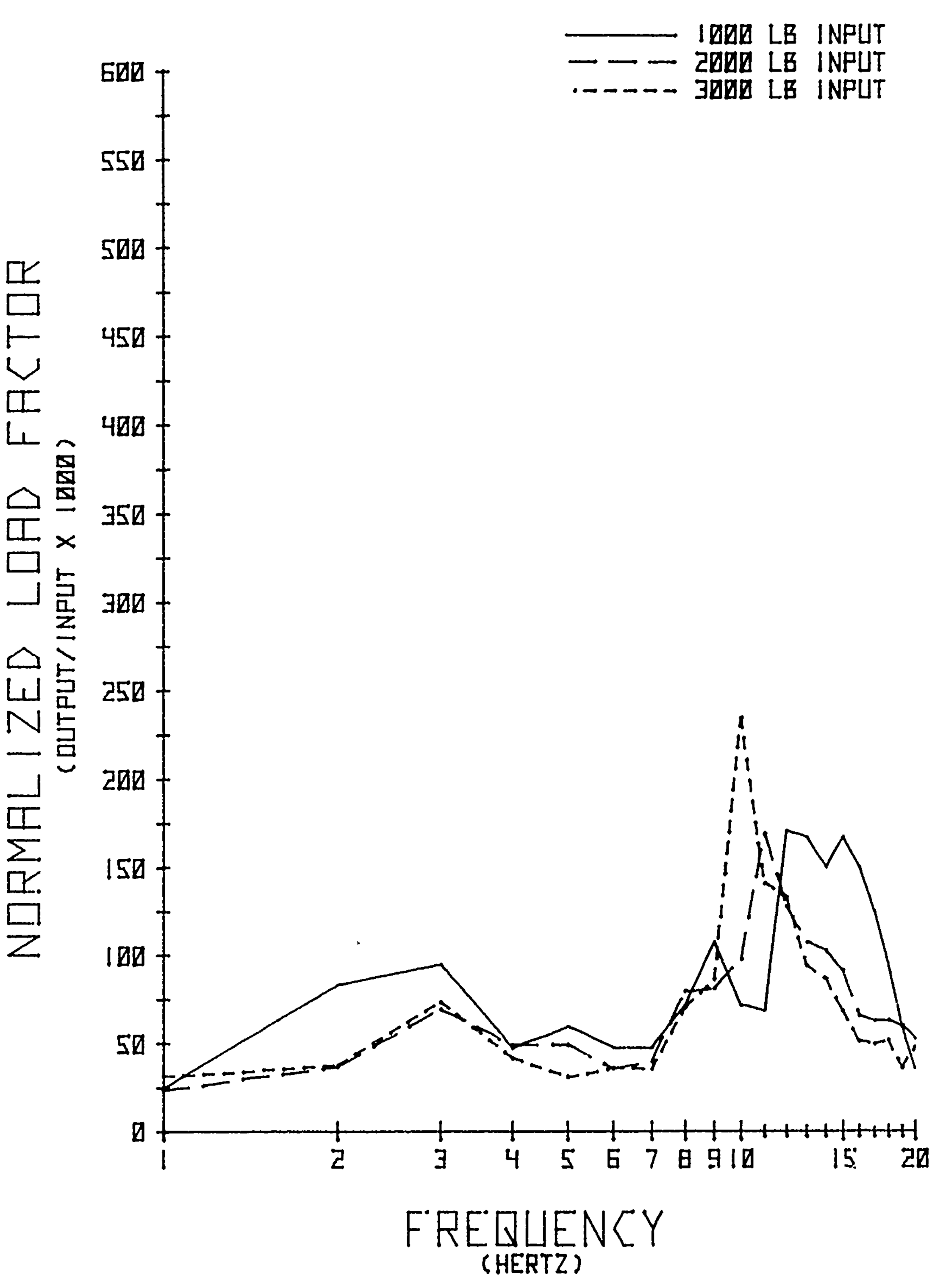

STRAIN LINK NO. 3
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

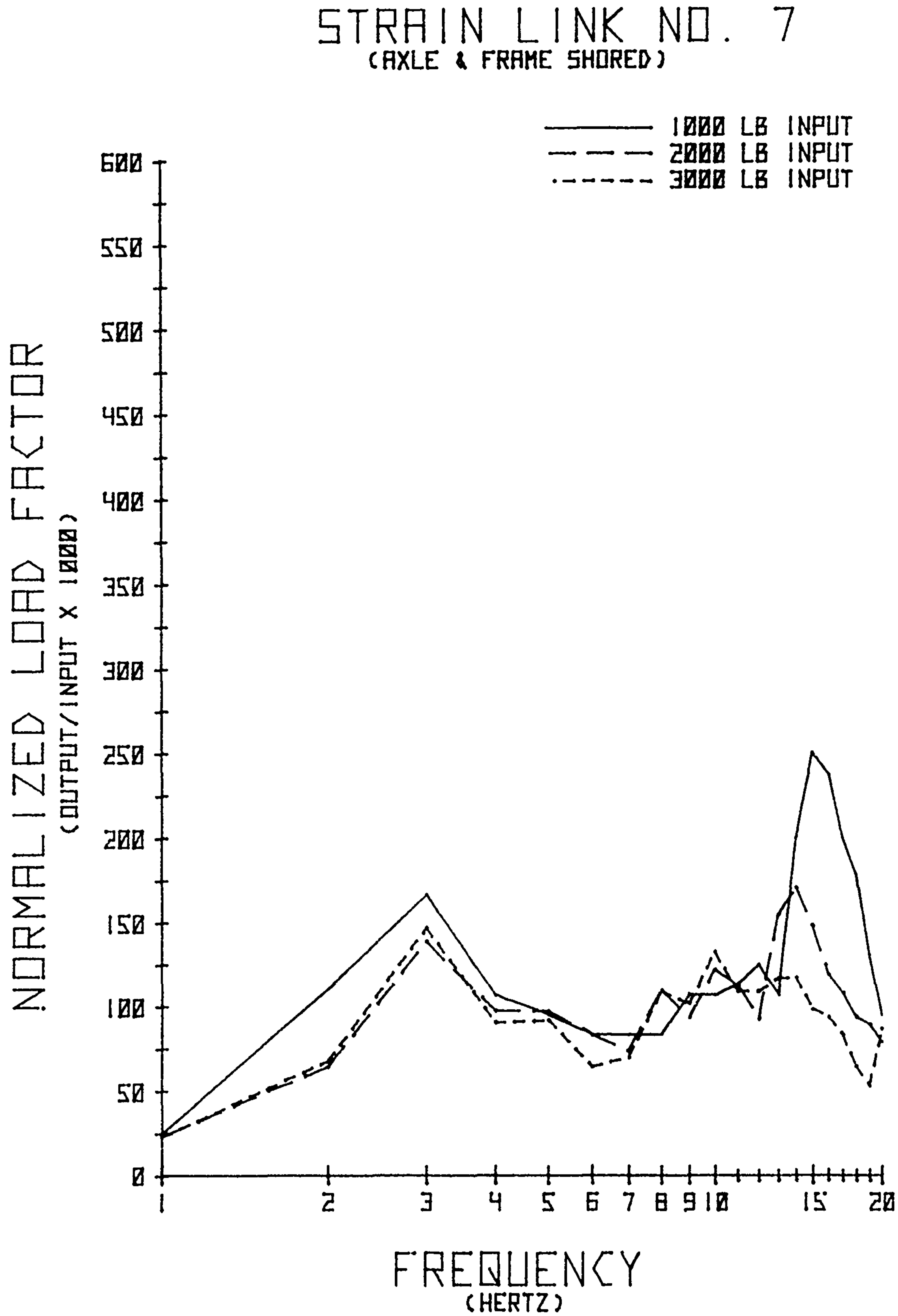


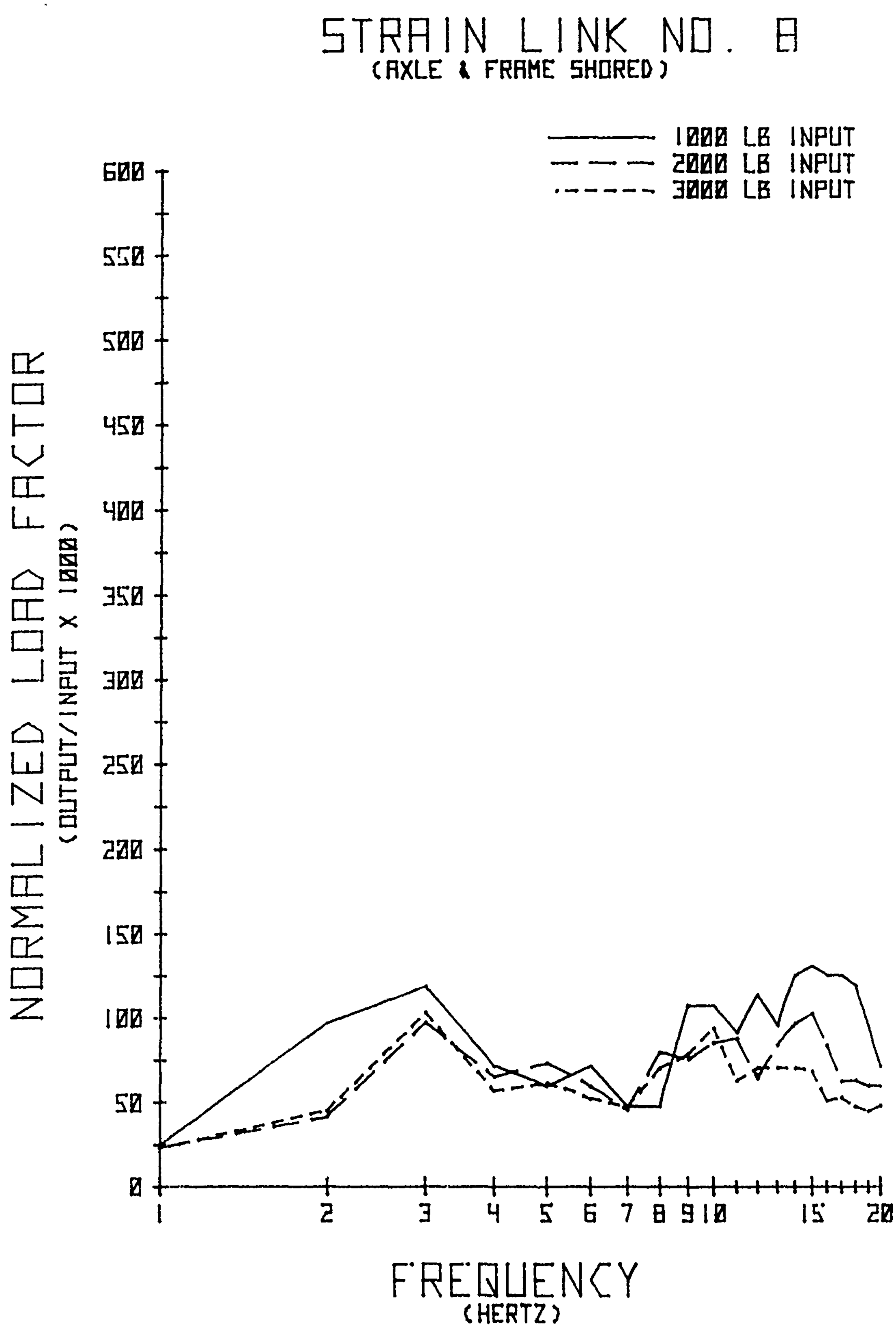
STRAIN LINK NO. 4
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
600
550
500
450
400
350
300
250
200
150
100
50
0
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

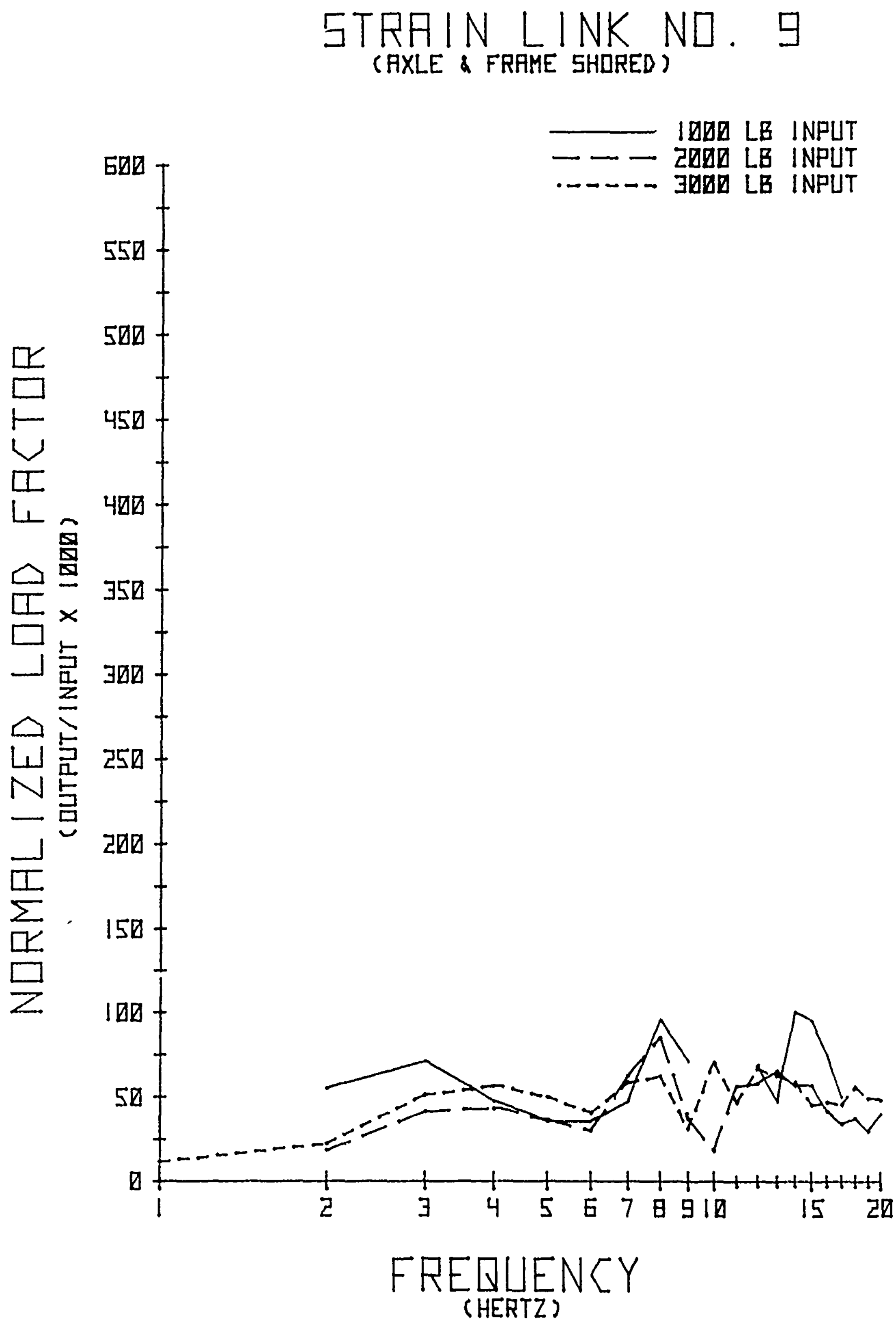


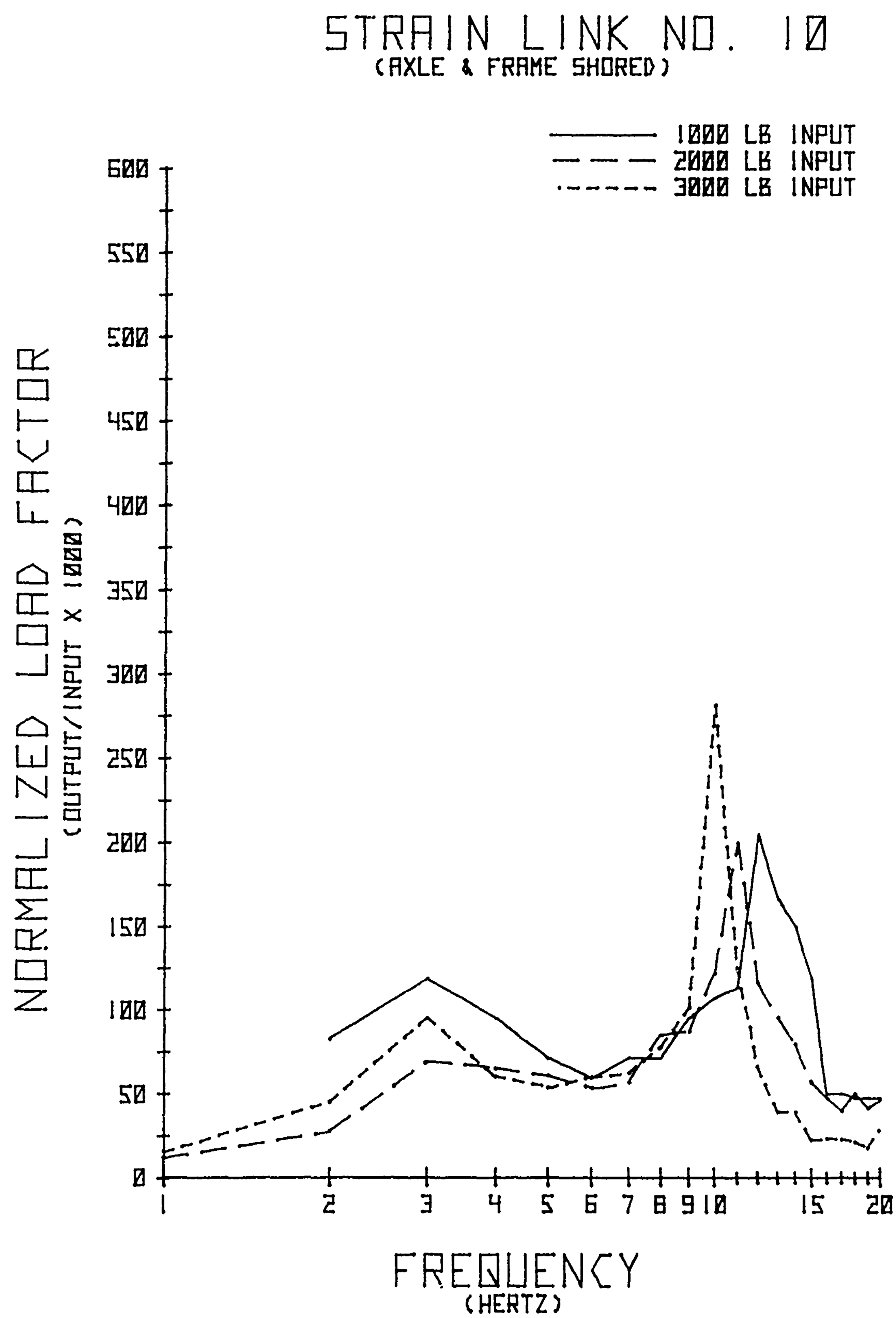
STRAIN LINK NO. 5
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. E
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

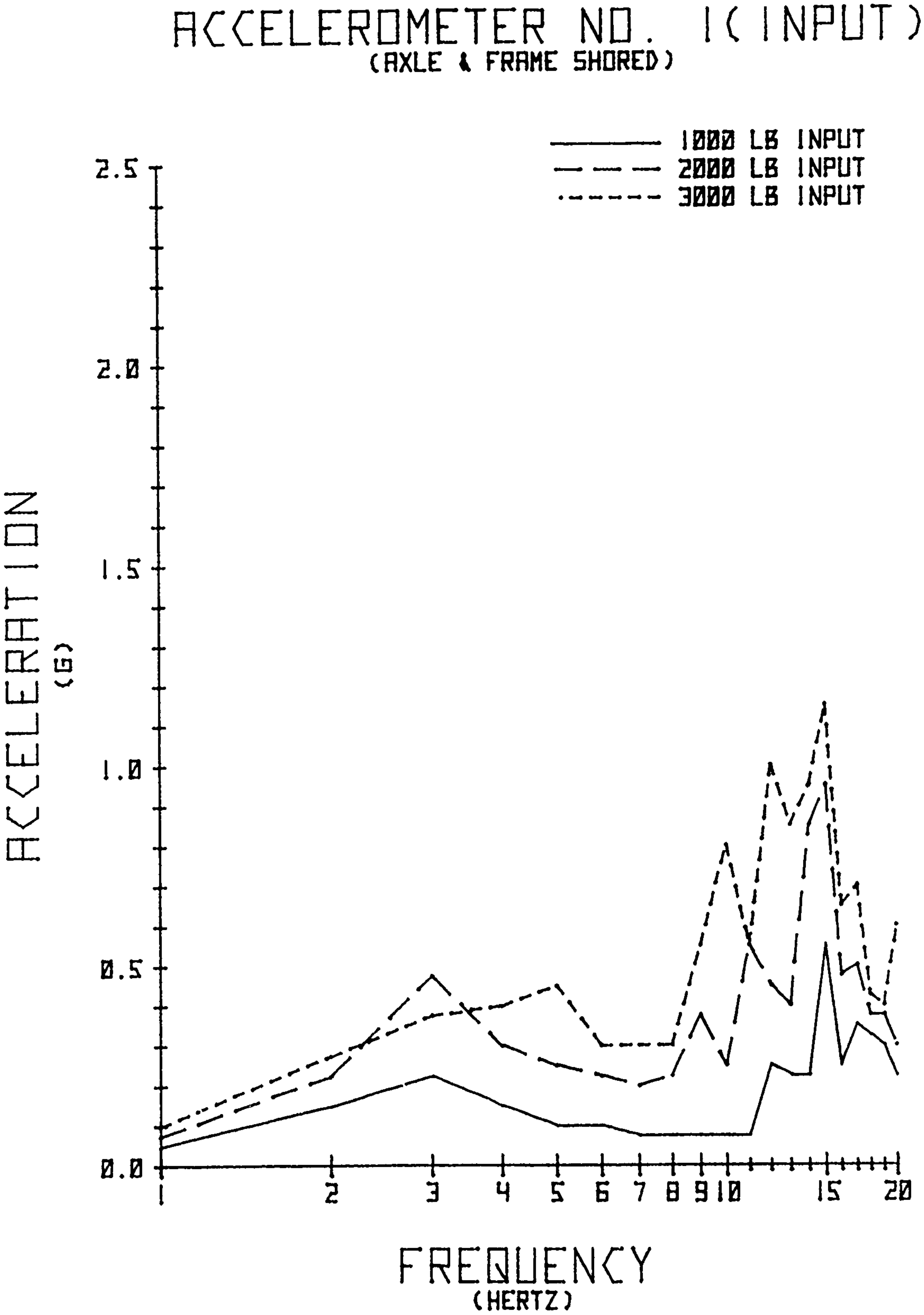

STRAIN LINK NO. 7
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

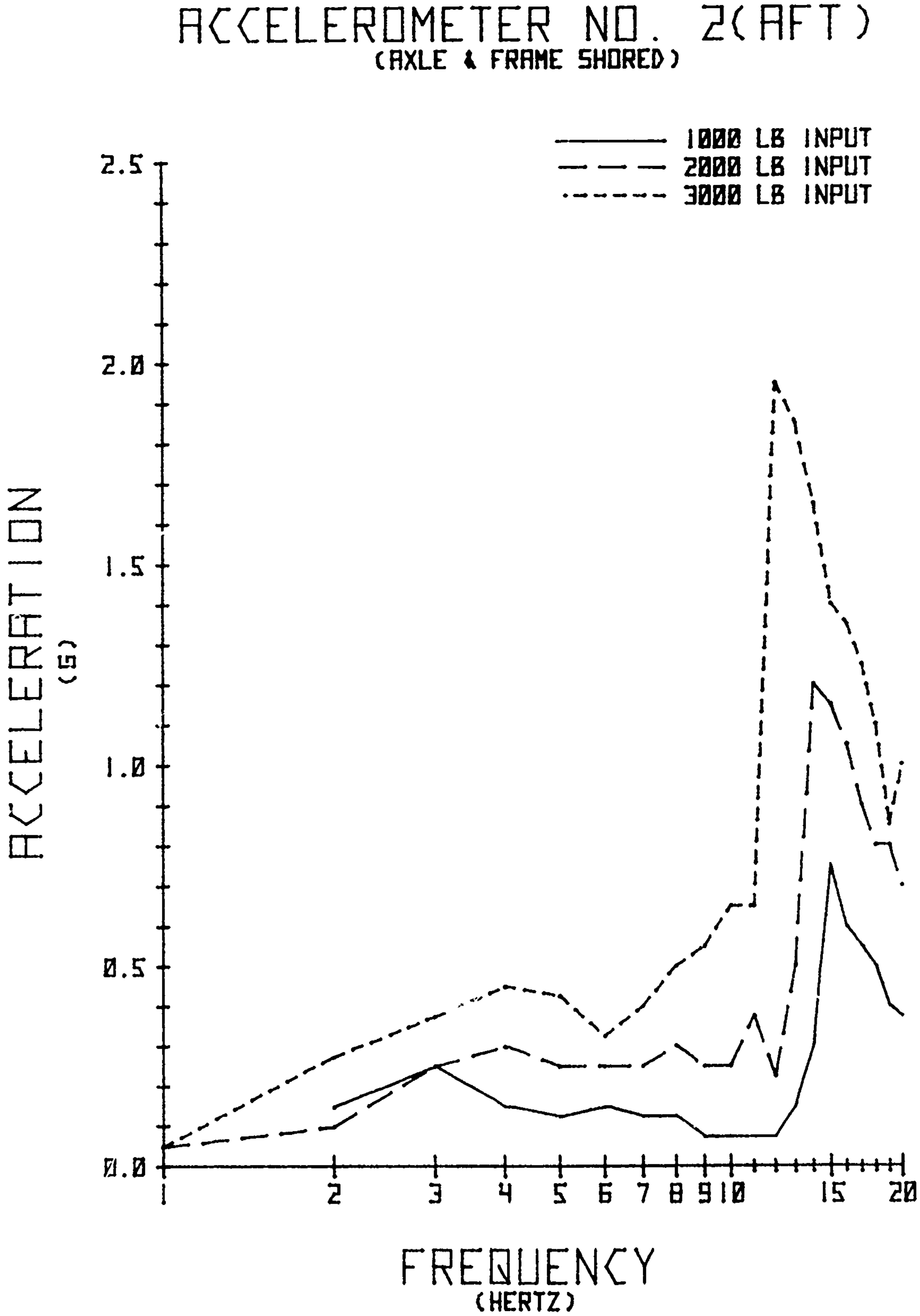

STRAIN LINK NO. 8
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

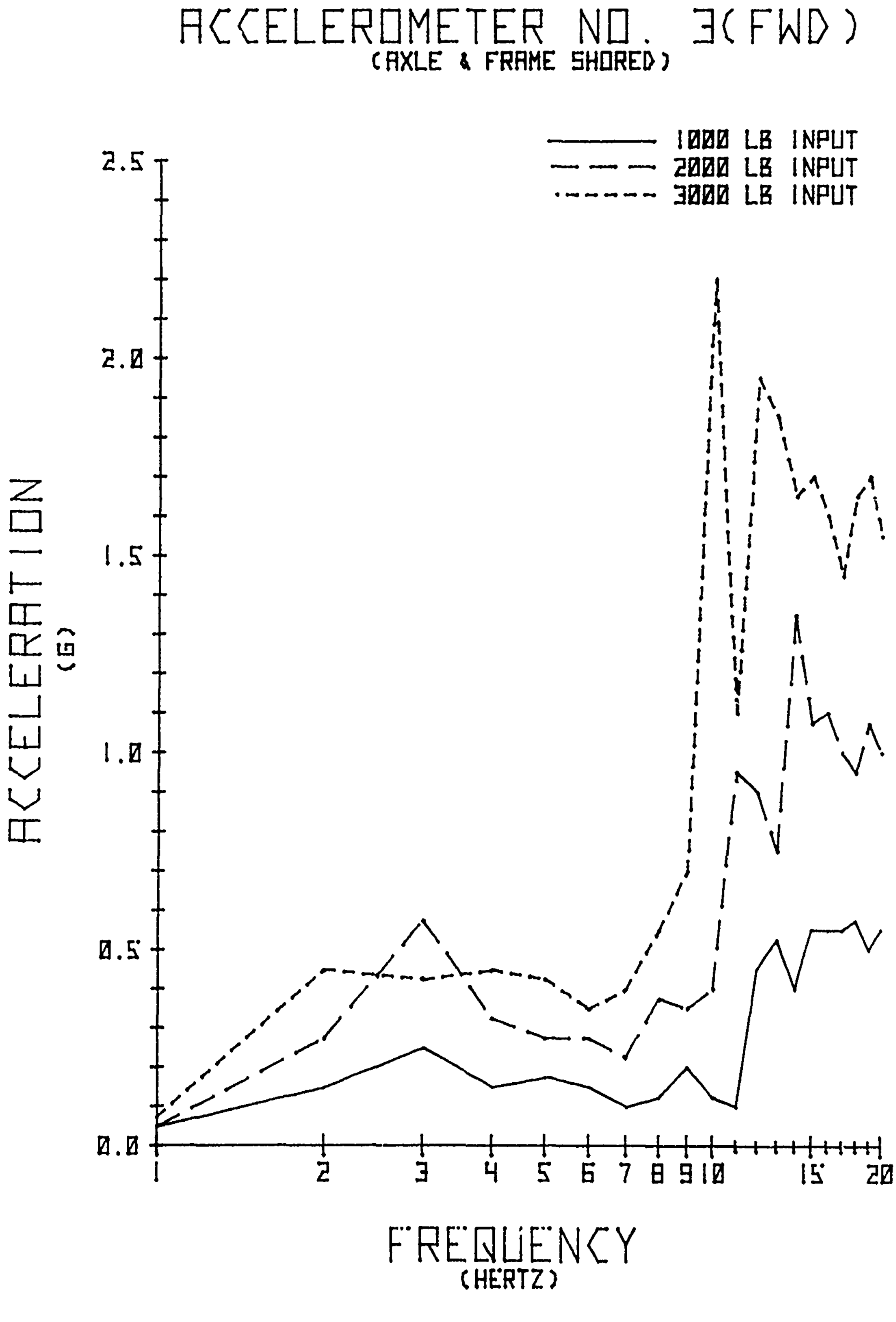

STRAIN LINK NO. 9
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

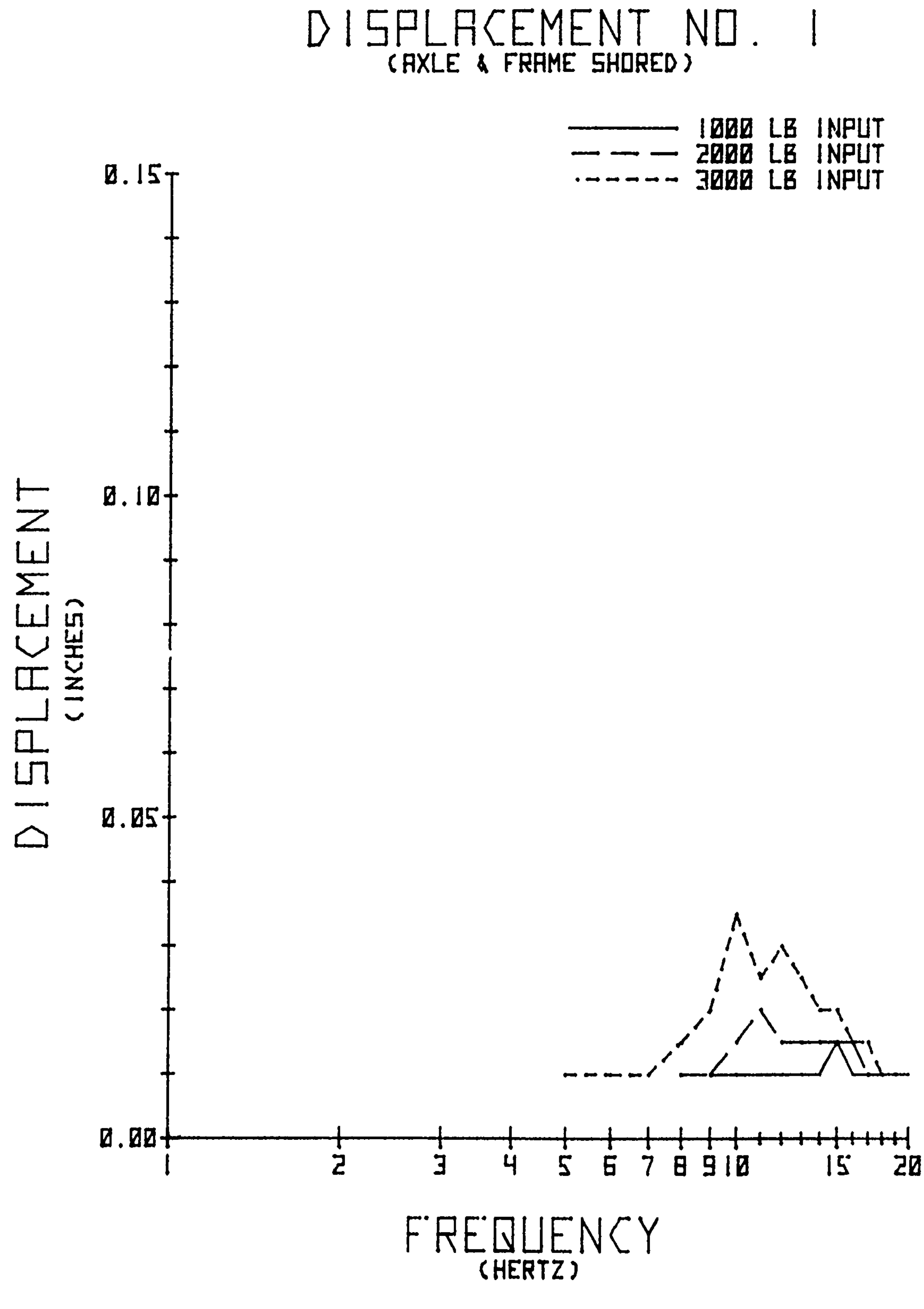


STRAIN LINK NO. 10
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
0
50
100
150
200
250
300
350
400
450
500
550
600
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

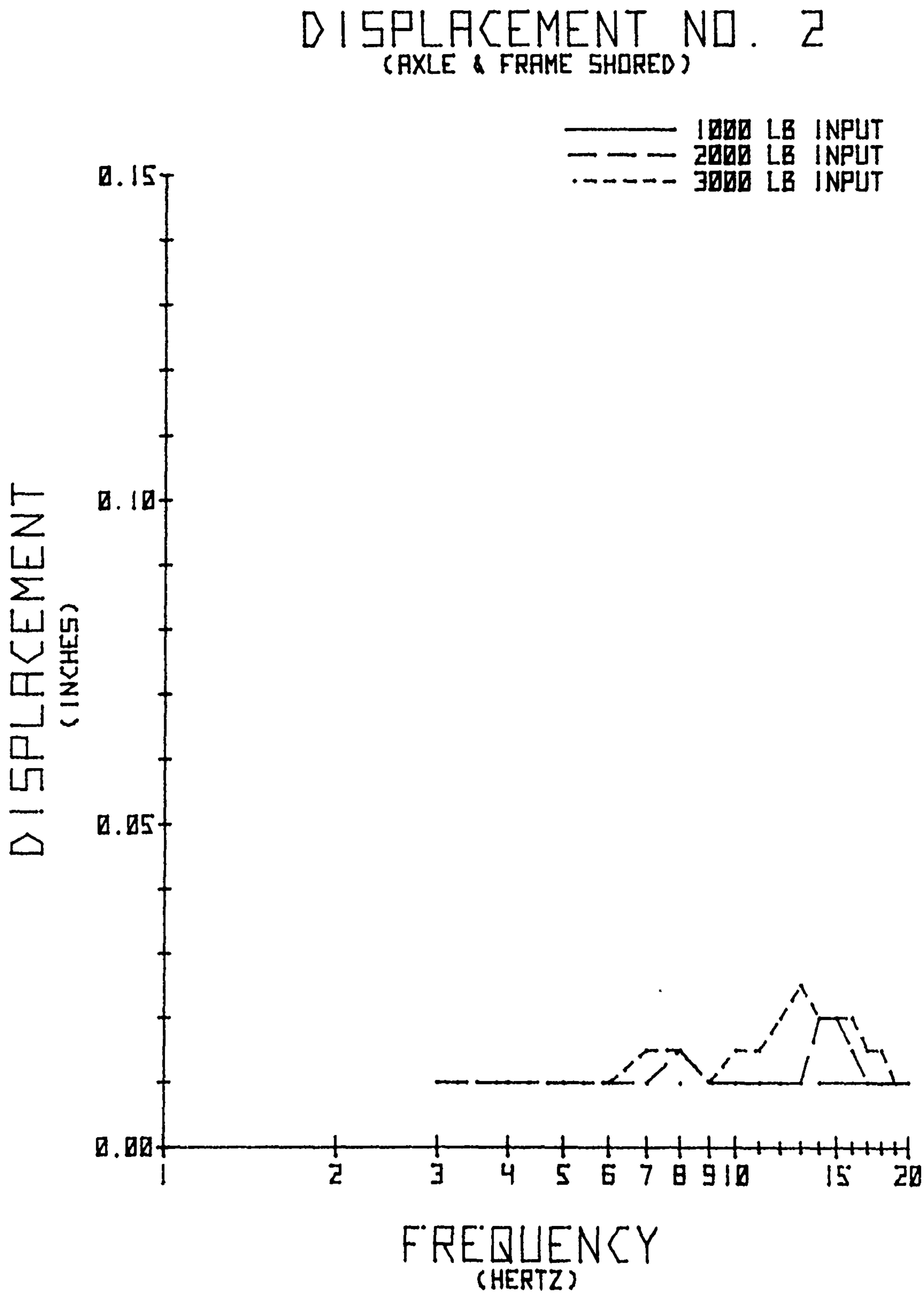

ACCELEROMETER NO. 1(INPUT)
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

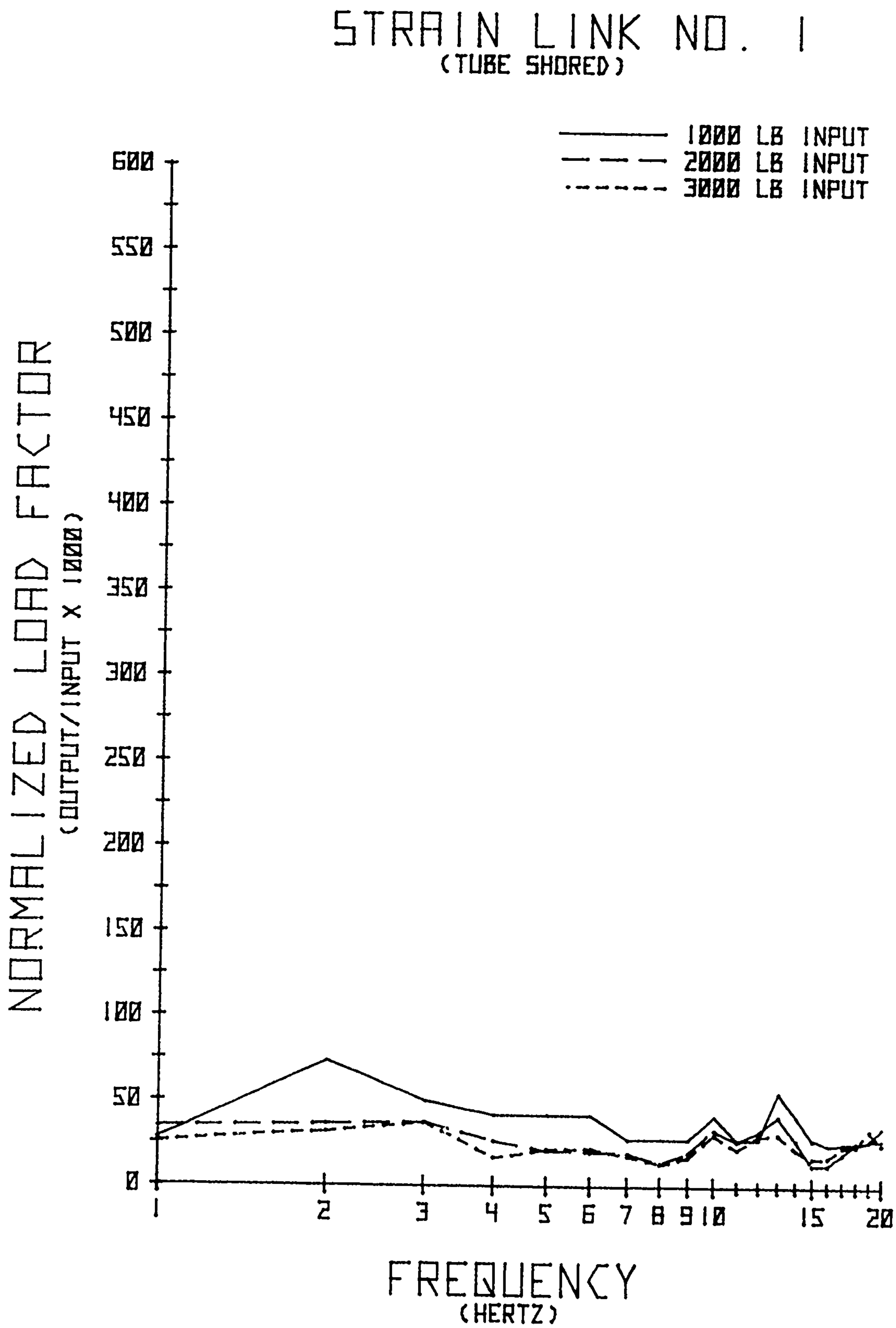

ACCELEROMETER NO. 2(AFT)
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

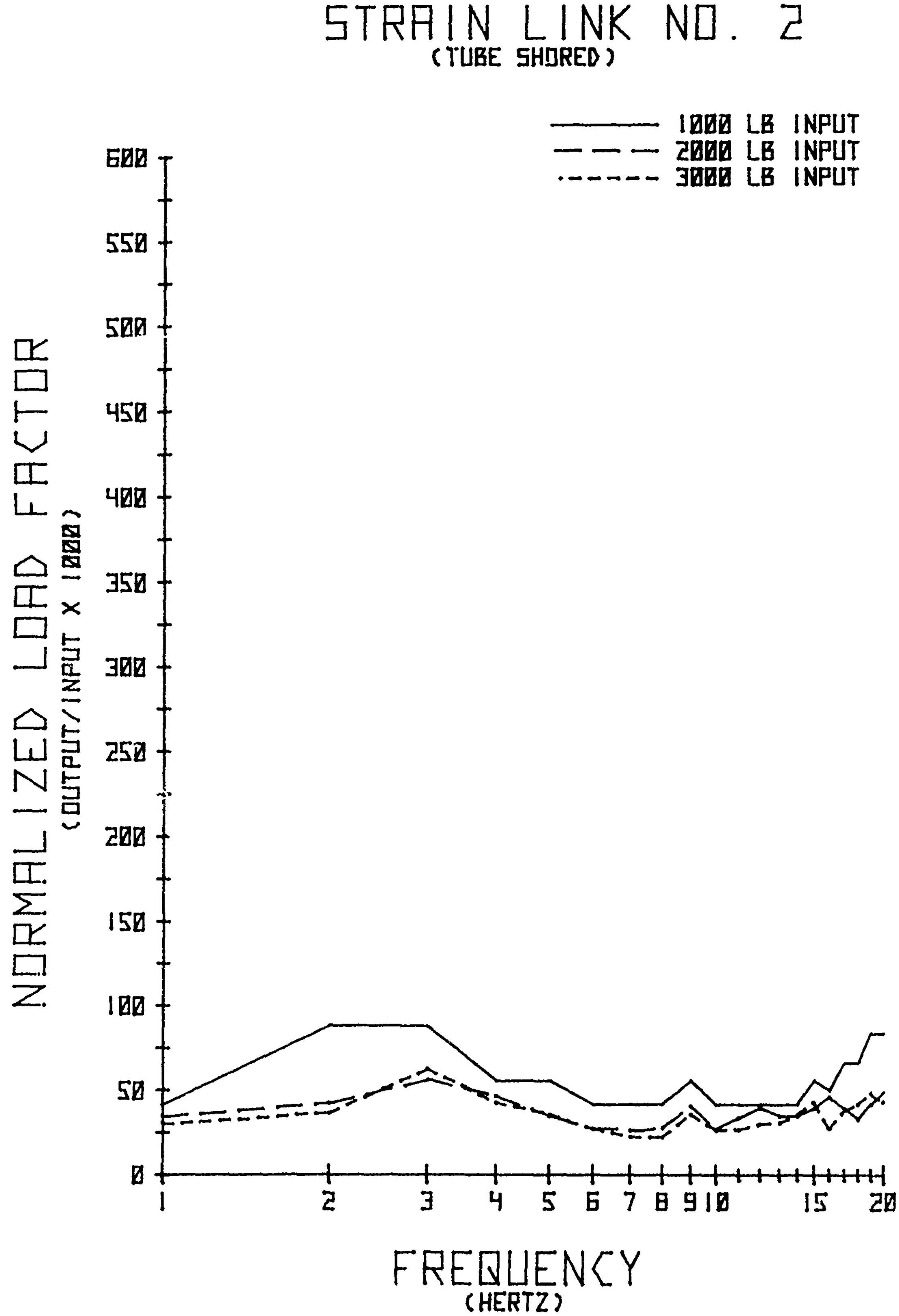

ACCELEROMETER NO. 3(FWD)
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



DISPLACEMENT NO. 1
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

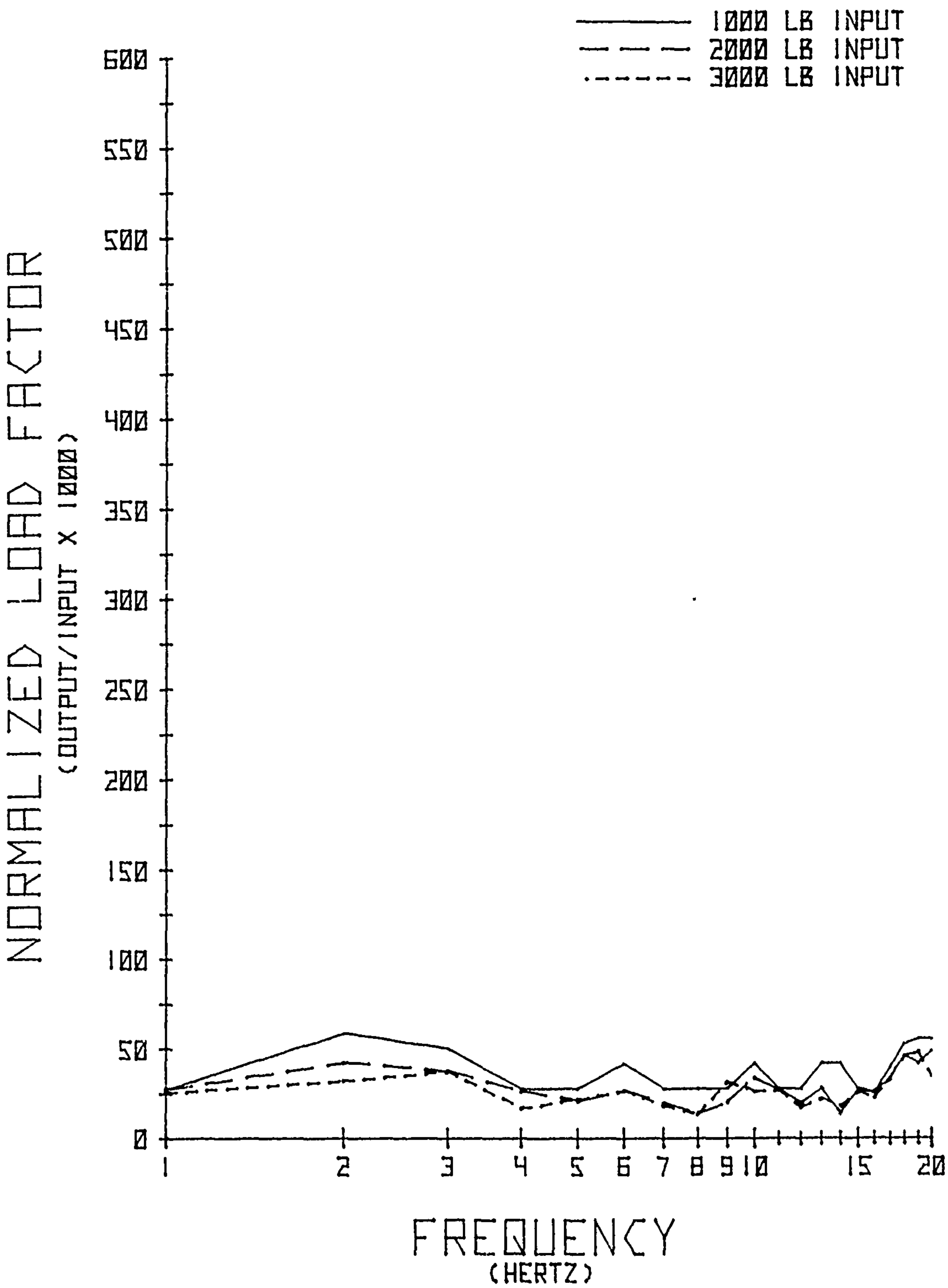

DISPLACEMENT NO. 2
(AXLE & FRAME SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

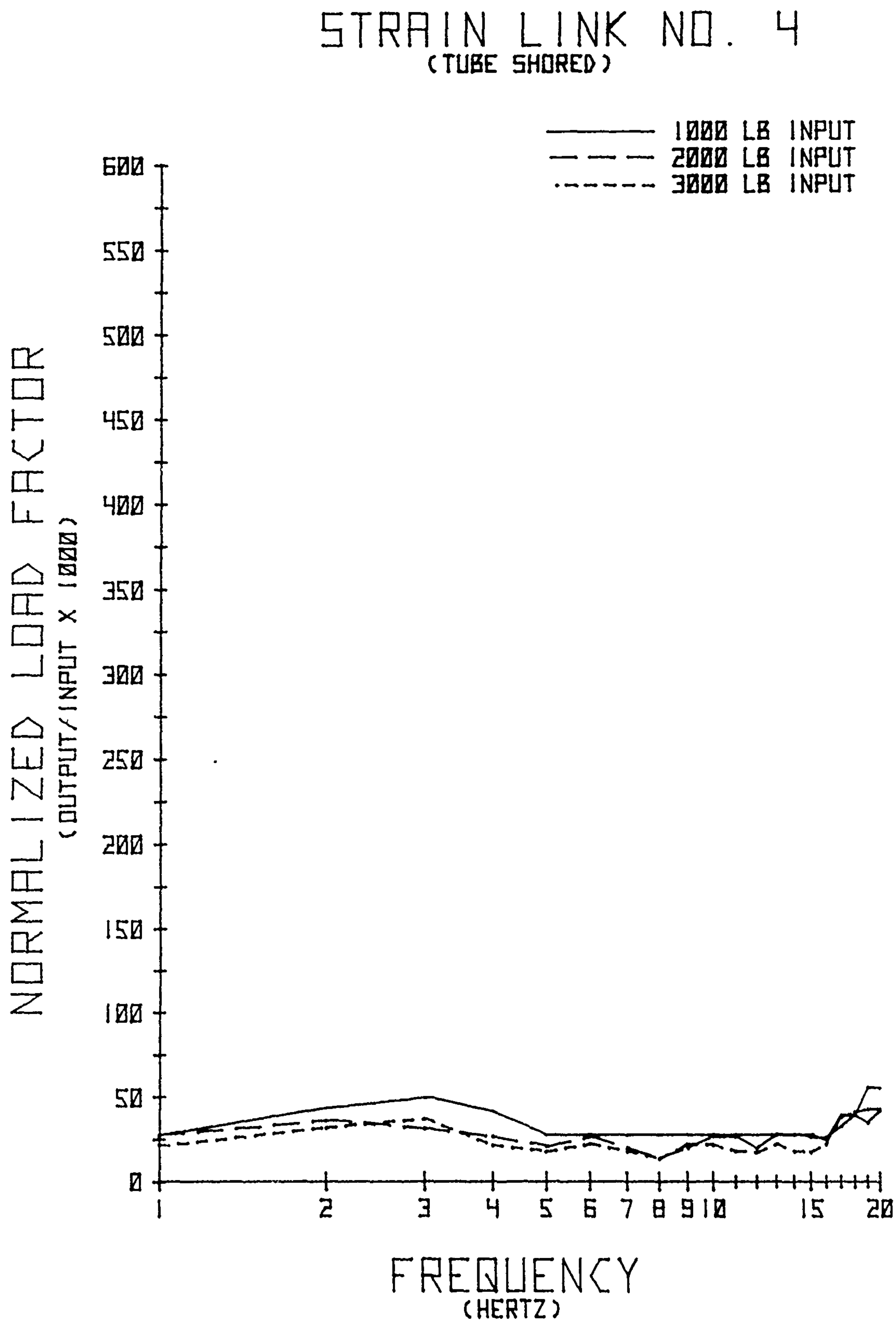

STRAIN LINK NO. 1
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



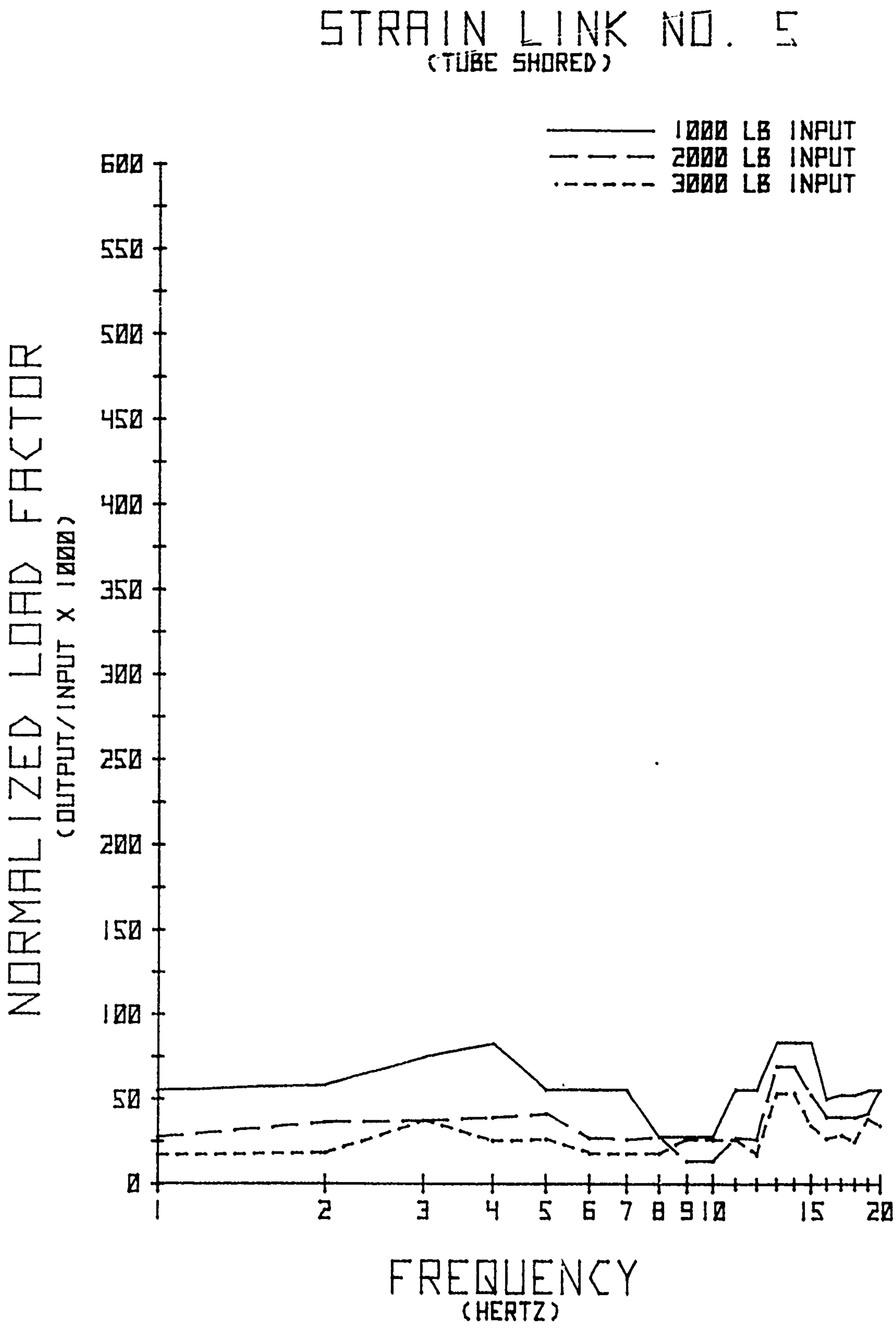
STRAIN LINK NO. 2
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

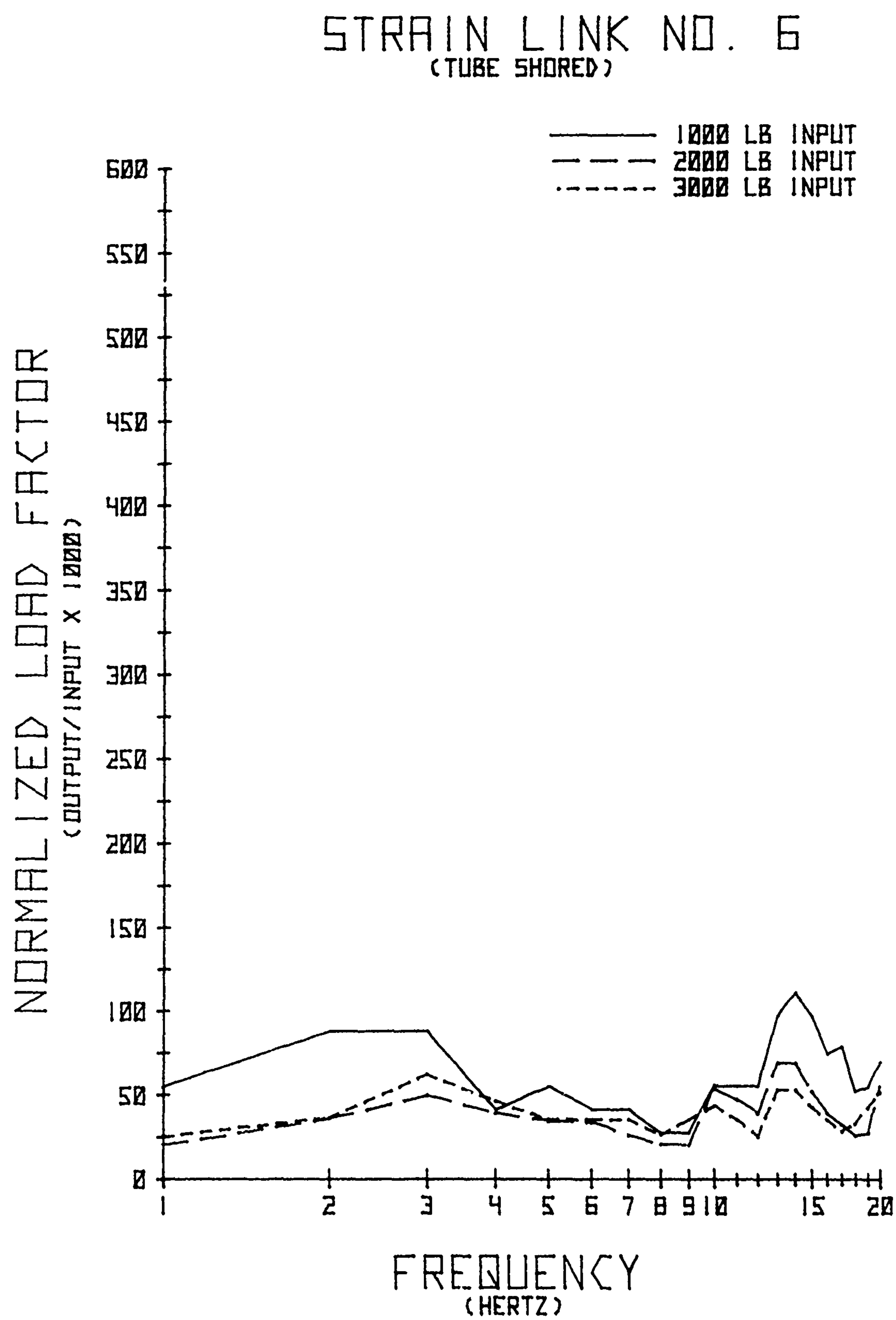
STRAIN LINK NO. 3
(TUBE SHORED)

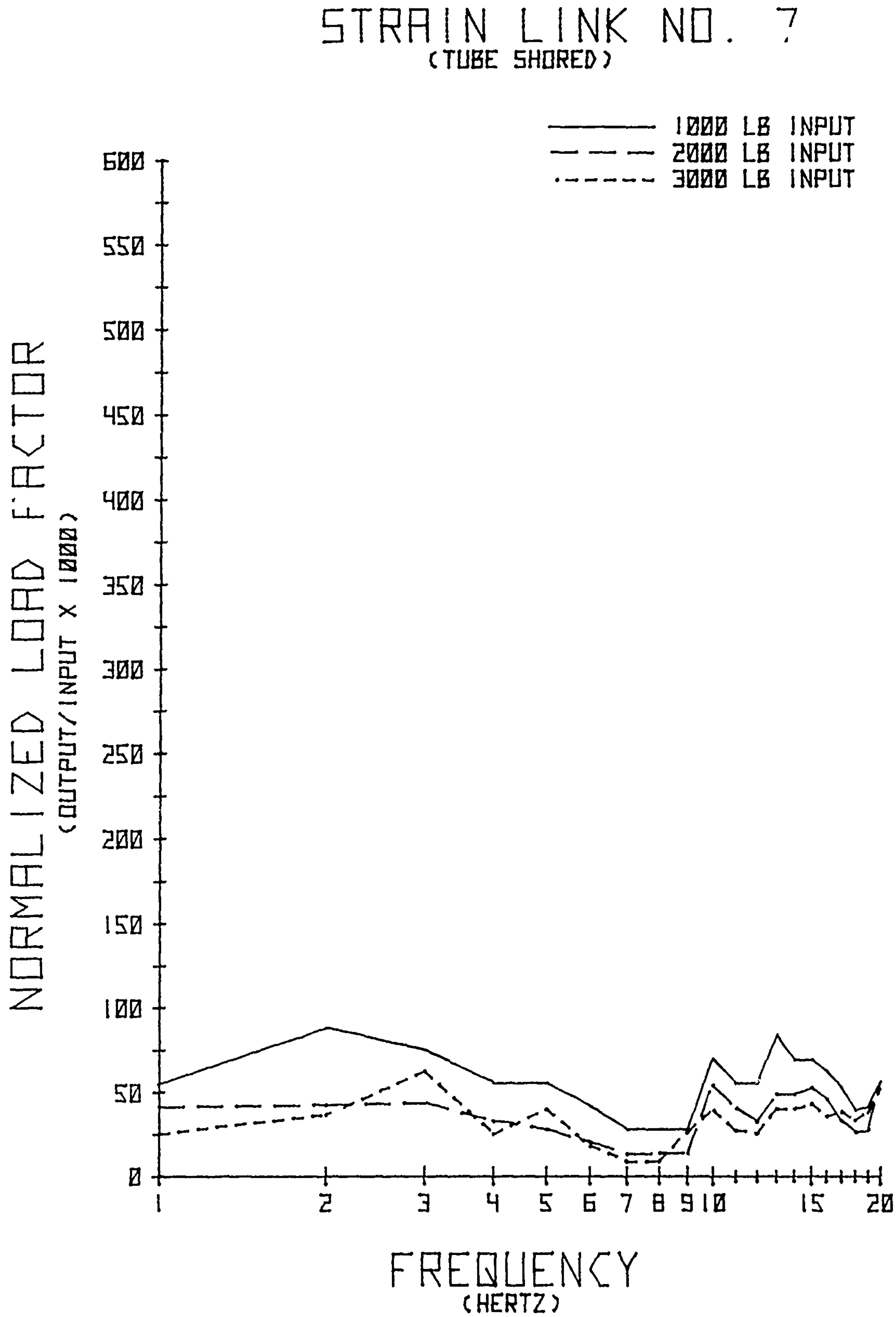




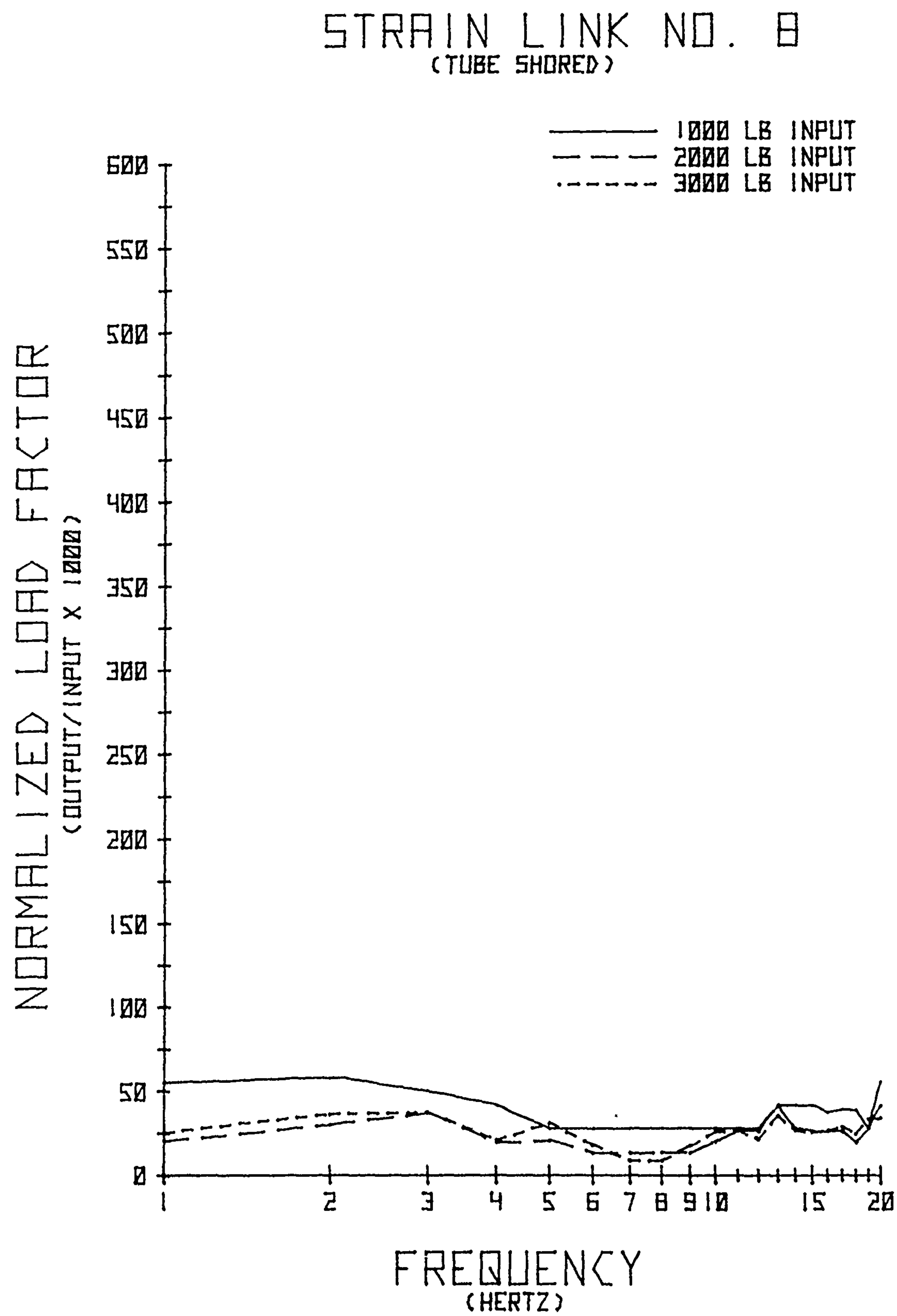
STRAIN LINK NO. 4
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


STRAIN LINK NO. 5
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
600
550
500
450
400
350
300
250
200
150
100
50
0
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

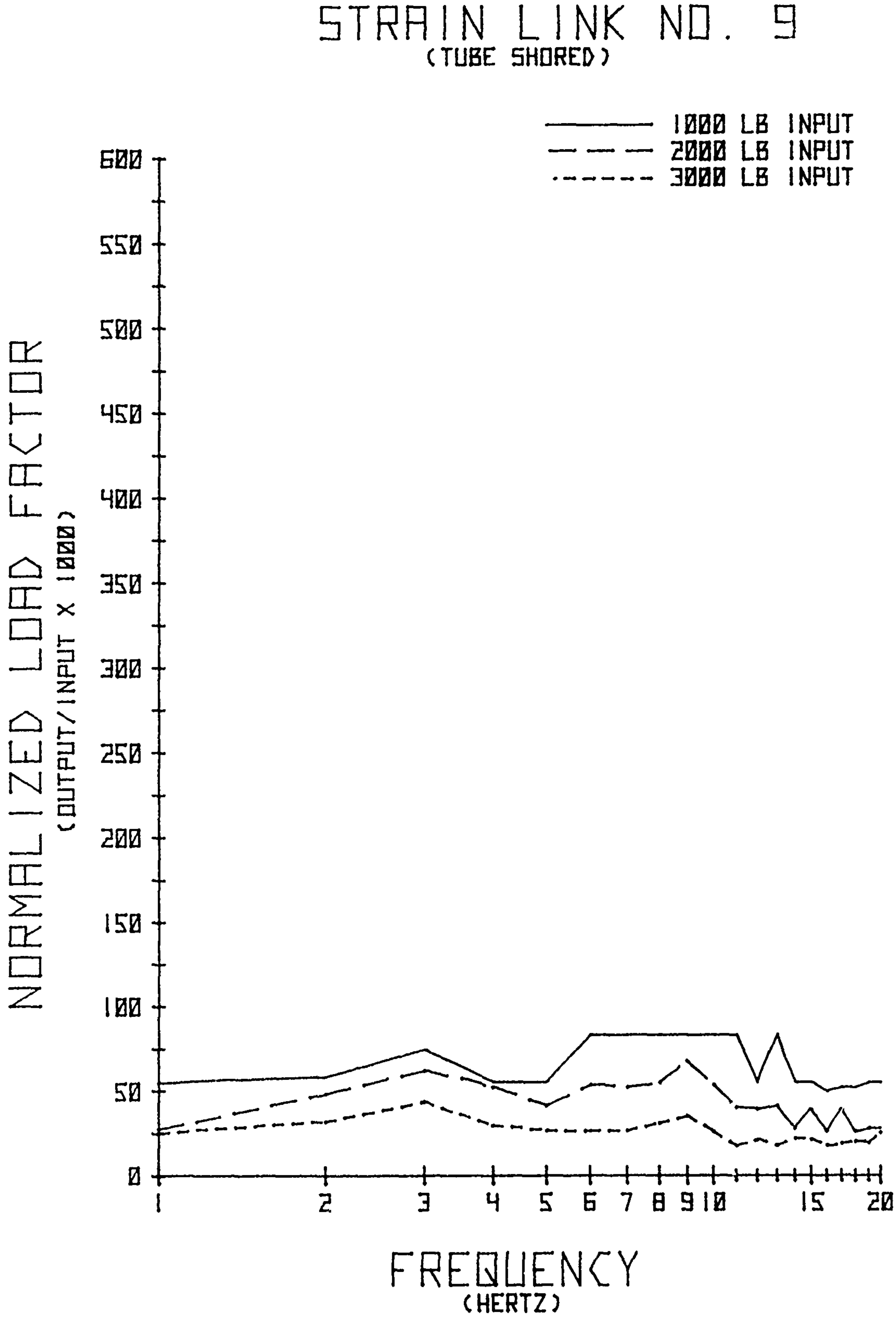

STRAIN LINK NO. 6
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



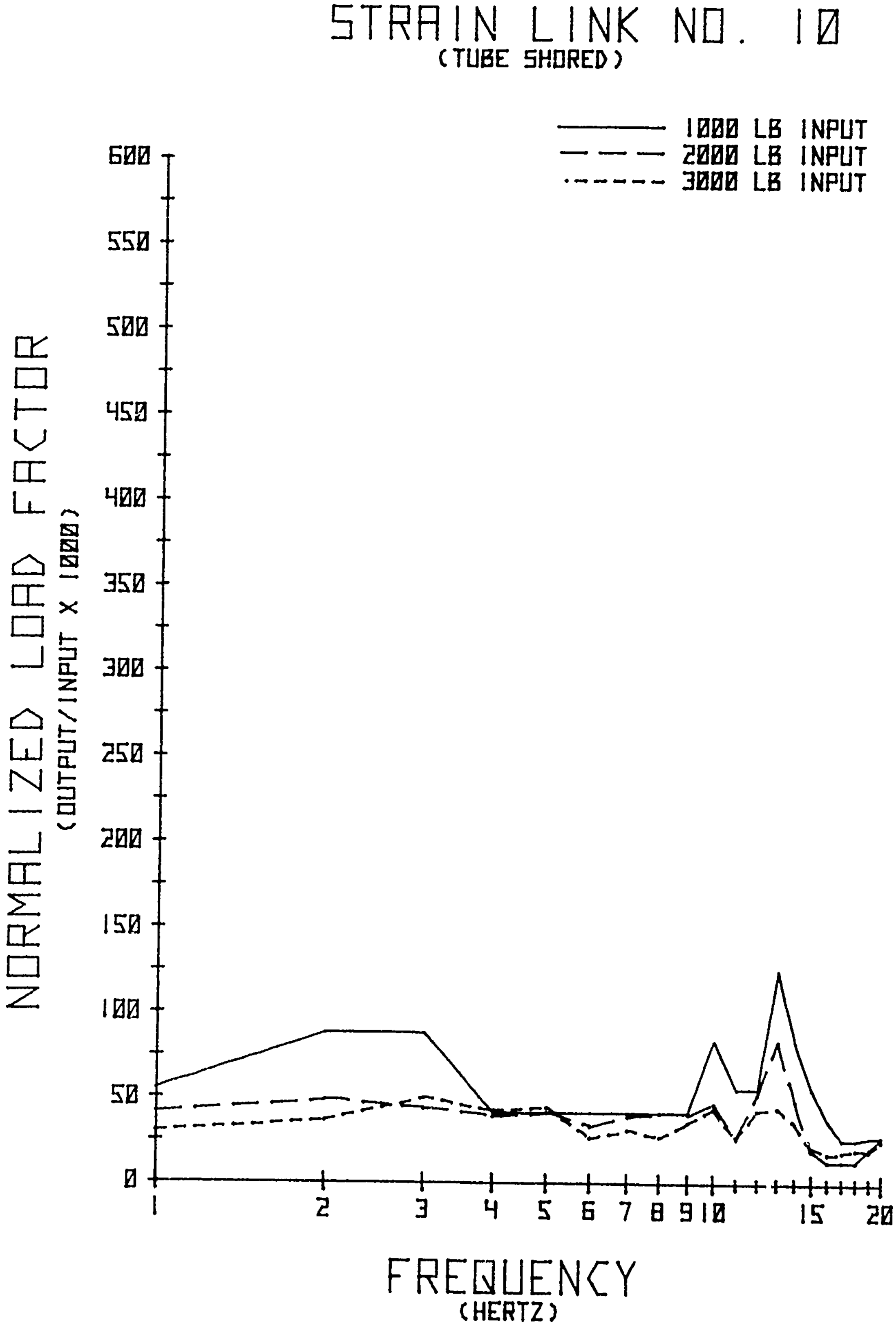
STRAIN LINK NO. 7
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



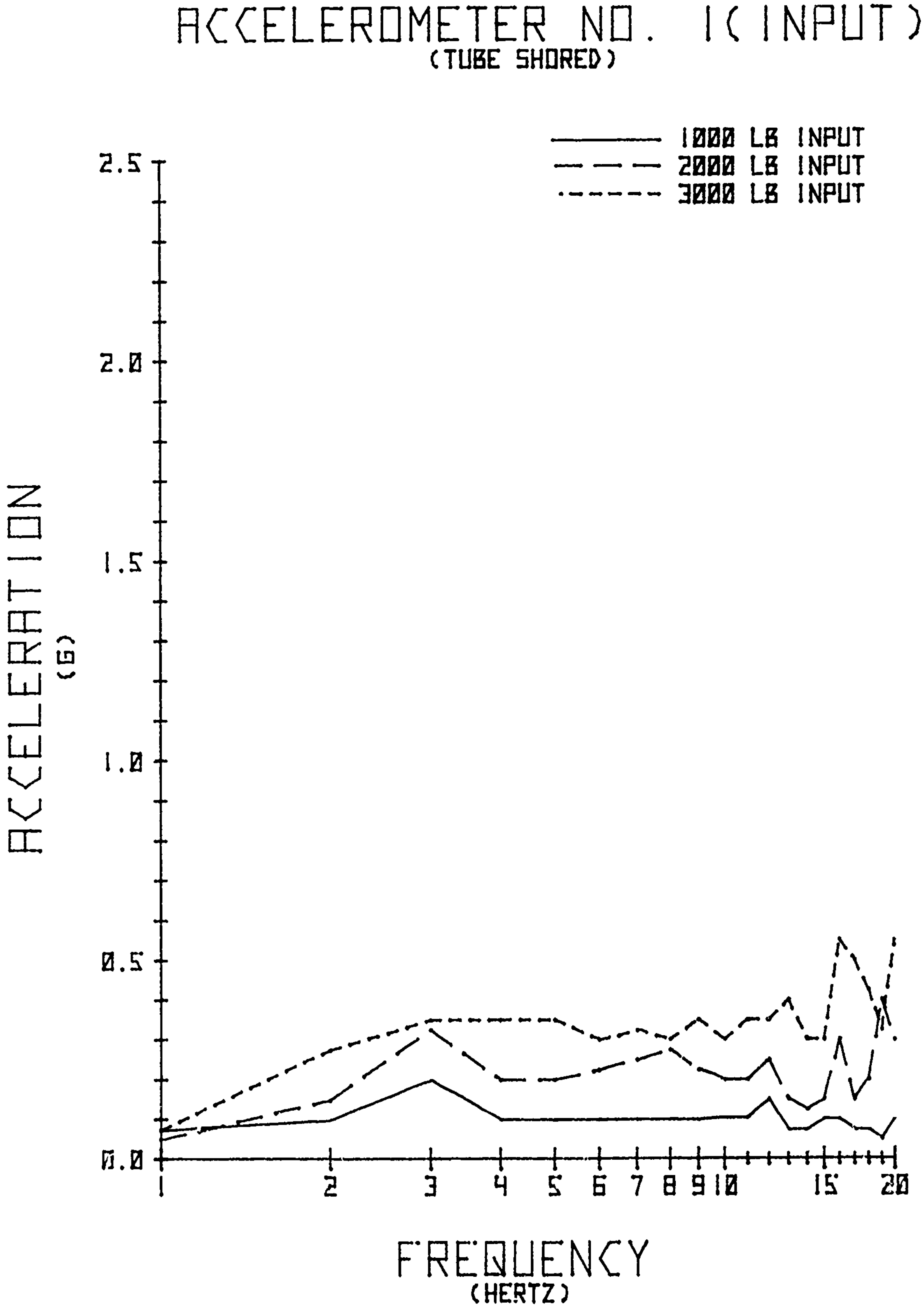
STRAIN LINK NO. 8
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



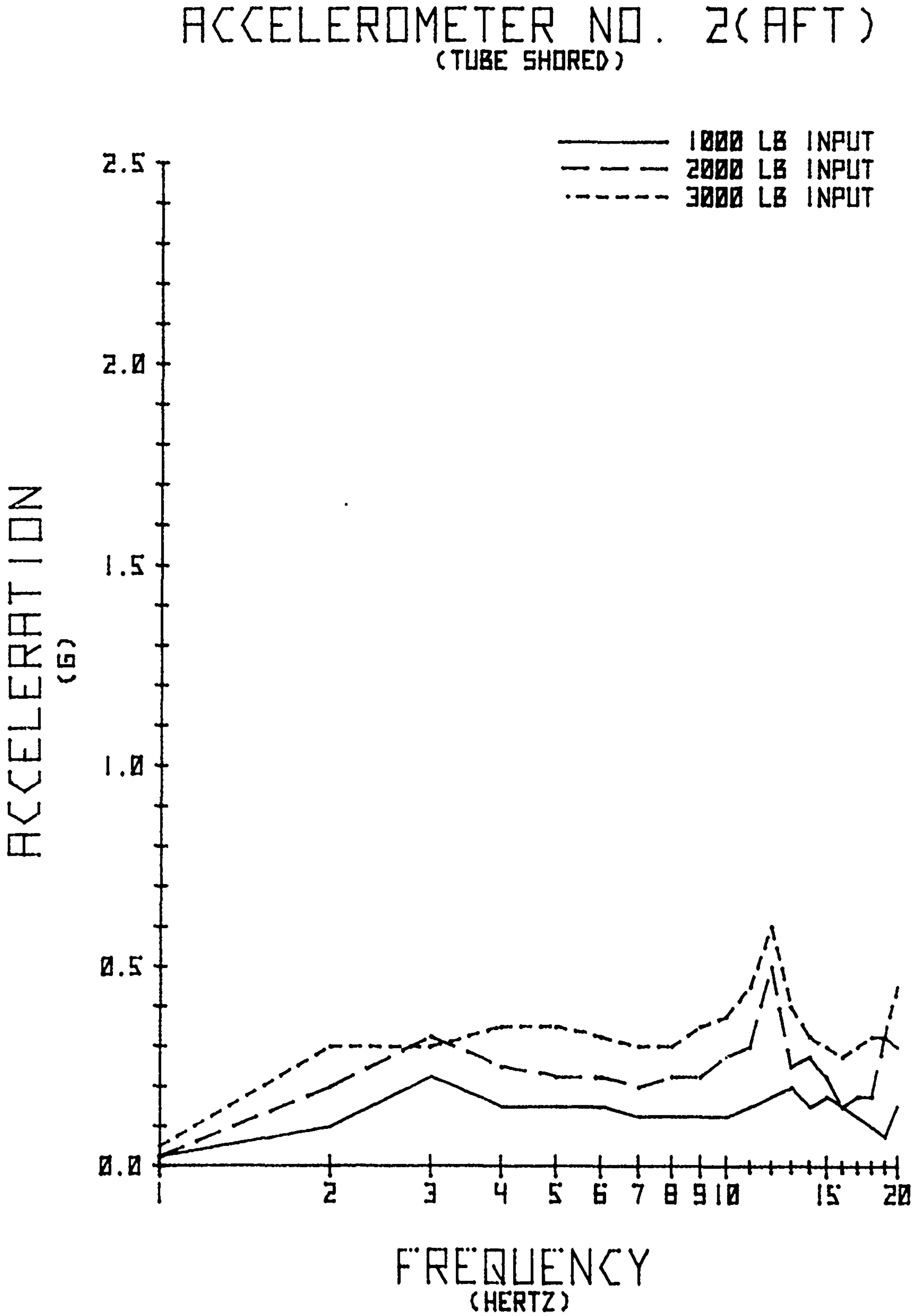
STRAIN LINK NO. 9
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



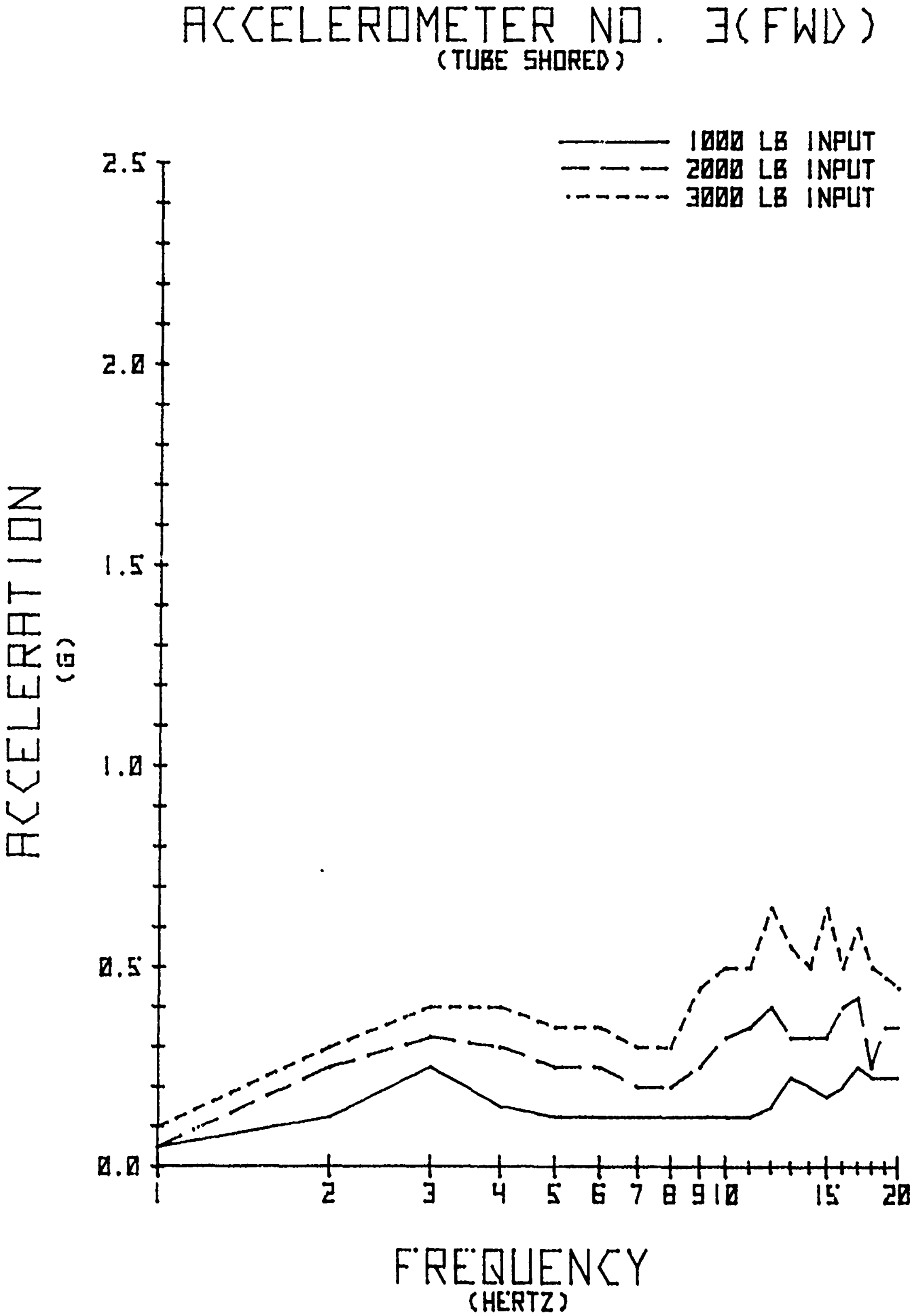
STRAIN LINK NO. 10
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
NORMALIZED LOAD FACTOR
(OUTPUT/INPUT X 1000)
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

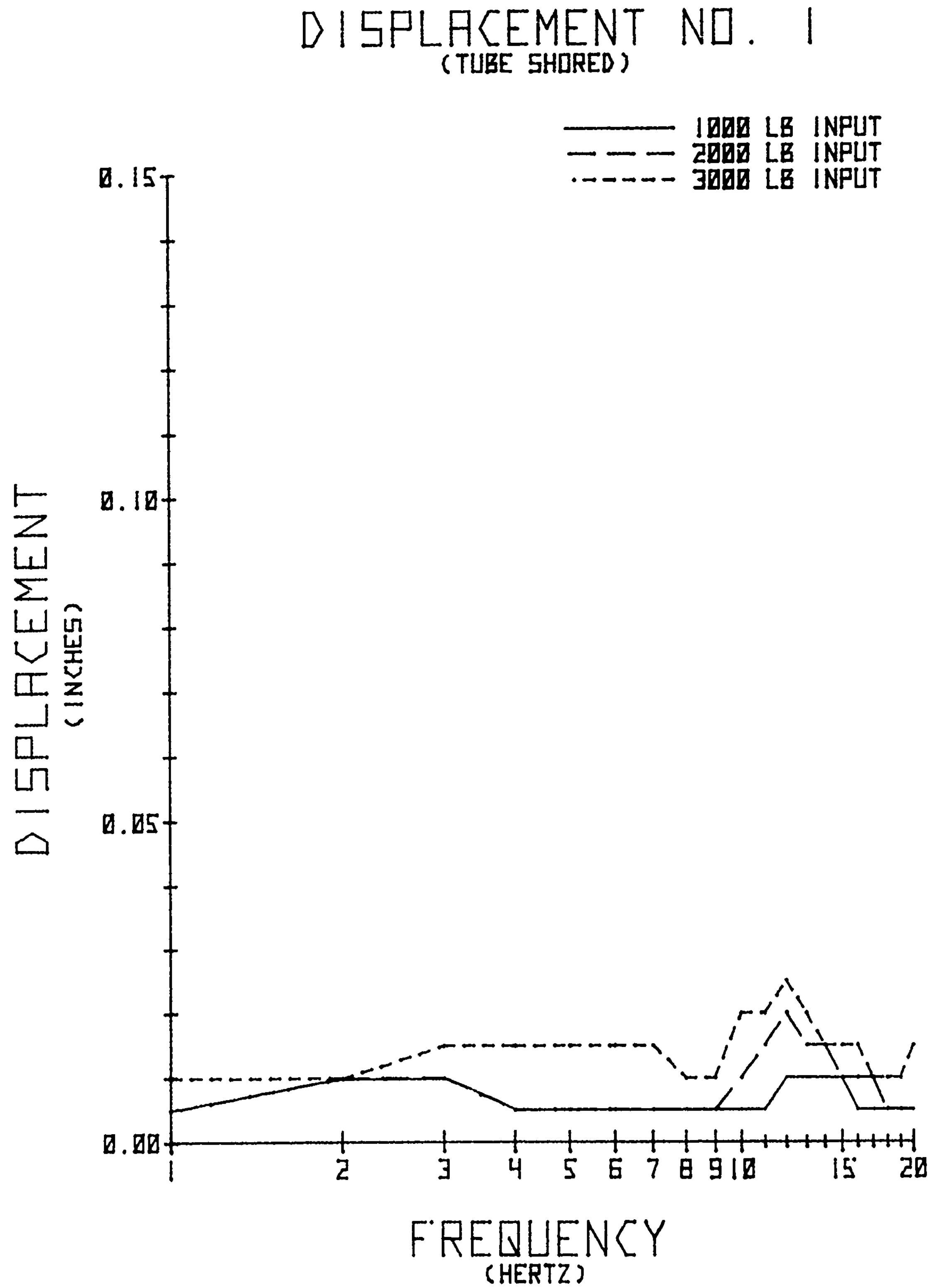


ACCELEROMETER NO. 1(INPUT)
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
2.5
2.0
1.5
1.0
0.5
0.0
ACCELERATION
(G)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)

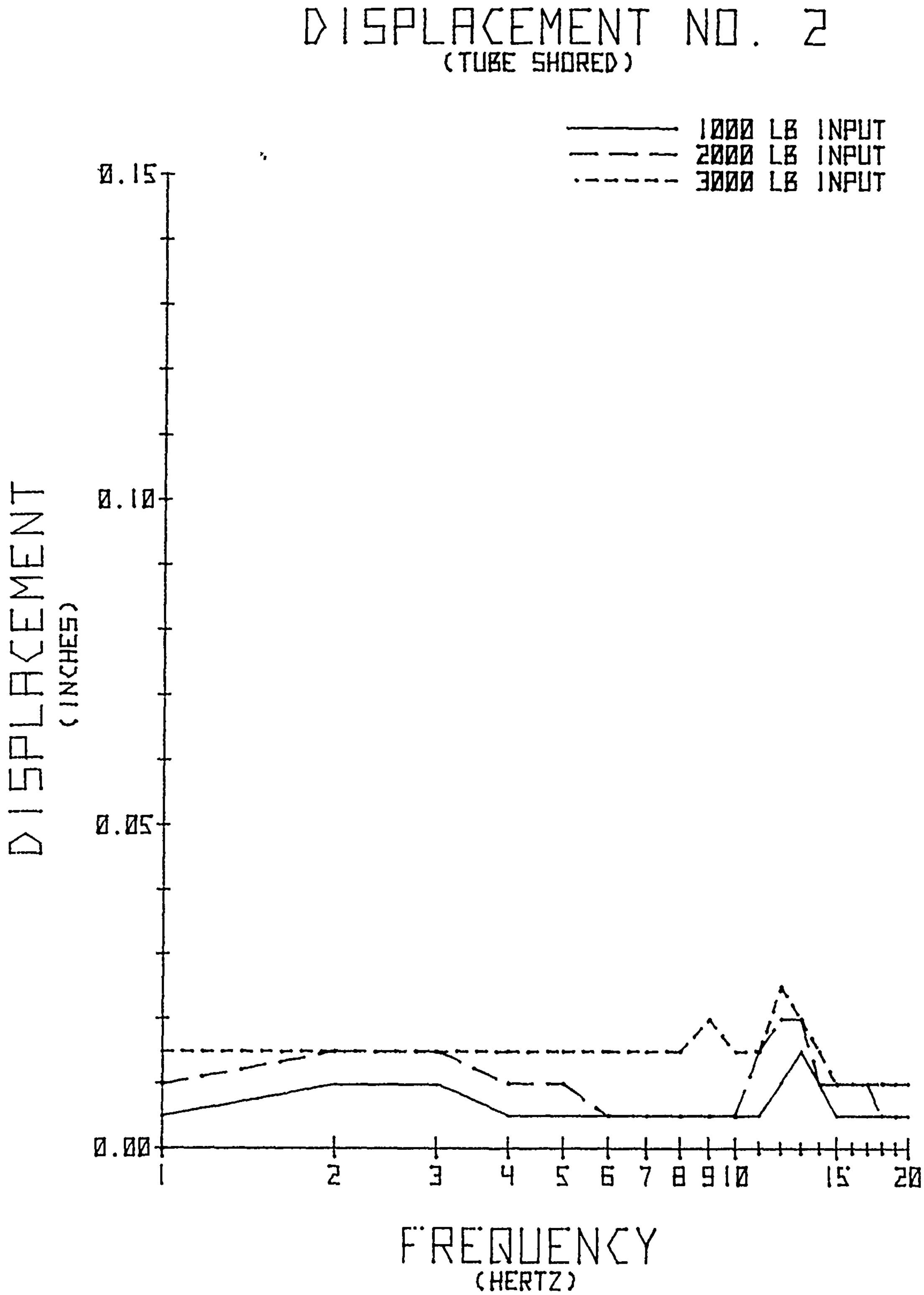


ACCELEROMETER NO. 2(AFT)
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


ACCELEROMETER NO. 3(FWD)
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
ACCELERATION
(G)
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)



DISPLACEMENT NO. 1
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
10
15
20
FREQUENCY
(HERTZ)


DISPLACEMENT NO. 2
(TUBE SHORED)
1000 LB INPUT
2000 LB INPUT
3000 LB INPUT
0.15
0.10
0.05
0.00
DISPLACEMENT
(INCHES)
1
2
3
4
5
6
7
8
9
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FREQUENCY
(HERTZ)